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SPEEDS AND FEEDS OF MACHINE TOOLS.

A SIMPLE AND QUICK METHOD FOR OBTAINING A GEOMETRICAL PROGRESSION OF SPEEDS AND FEEDS IN MACHINE DRIVES—SOME SUGGESTIONS FOR MACHINE TOOL DESIGNERS.

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In designing machine tools of any type, be it a lathe, milling machine, grinding machine, etc., aside from the correct proportioning of the parts, and the introduction of convenient means for rapidly producing certain motions, a very important factor is to be taken into consideration. I refer to the correct proportioning of the speeds and feeds of these various machines.

Before entering into an explanation of the method which is to be set forth later, I should like to explain some of the preliminary considerations which are to be met by the designer.

Supposing a problem of designing a lathe be presented, it follows, at once, that certain conditions limiting the problem are also given. These limiting conditions may be considered as the size and material of the piece to be turned.

We consider the material of a piece to be machined as a limiting condition for the reason, that a lathe turning wood must run at a different speed from one turning brass, and the latter at a different speed from a lathe turning iron or steel. Then, again, in turning a small piece our machine will revolve faster than in turning a large piece. The speeds required for machining advantageously the different materials, according to the different diameters, may be termed "surface speeds." Roughly speaking, the surface speeds for the different materials vary in comparatively narrow limits. We may assume the following speeds for the following materials:

Cast iron...........	30 to 45 feet per minute	(9.14 to 13.71 m.)
Steel............ ...	20 to 25 feet per minute	(6.09 to 7.62 m.)
Wrought iron.......	30 feet per minute	(9.14 m.)
Brass...............	40 to 60 feet per minute	(12.19 to 18.28 m.)

For cast-iron as found in Europe, we may assume 20 to 35 feet per minute (6.09 to 10.67 m.) This is owing to the fact that European iron is considerably harder.

The surface speeds above given are, of course, approximate, and it is left to the judgment of the designer, to modify them according to the special given conditions. These surface speeds for cutting metal are the same whether the piece to be cut revolves, or the cutting tool revolves around the piece, or, as in a planer, the cutting tool moves in a straight line along or over the work. Therefore, the surface speeds in a general sense hold good for all types of machines, such as milling machines, lathes, gear cutting machines, drilling machines, planers, etc.

Referring to the two tables printed on pages 262 and 263, we find the surface speeds calculated for different diameters at different revolutions per minute. One table treats of speeds for a piece from one-quarter of an inch to twelve inches in diameter; the other treats of speeds for a piece from twelve inches to one hundred and twenty inches, or ten feet in diameter, giving the various speeds approximately between ten and eighty feet.

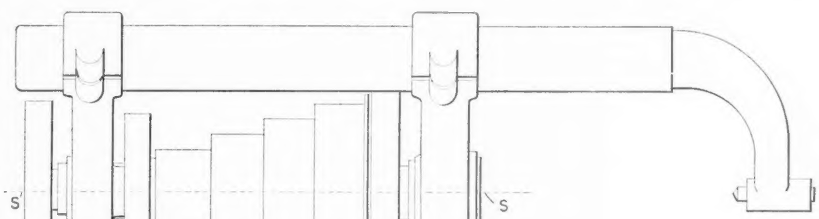


FIG. 1. ILLUSTRATING MILLING MACHINE FEEDS.

To illustrate the use of these tables let us assume that the problem is given to design a lathe to turn both cast-iron and steel, and to turn pieces from one-half of an inch to twelve inches in diameter. By referring to the table we find that a piece one-half an inch in diameter, to have the surface speed of cast iron, must make two hundred and thirty revolutions per minute. (Thirty feet per minute surface speed.) A piece of steel, which is twelve inches in diameter, with a surface speed of twenty feet per minute, must make 6.5 revolutions per minute. It follows, therefore, that the lathe to conform to the conditions imposed, must have speeds of the spindle varying from 6.5 to 230 revolutions per minute. The tables have been calculated for the solution of such problems, but they can also be used to advantage in the shop in determining the surface speed of machines in operation. By measuring the diameter of the cutter, and in counting the revolutions per minute, the table will at once give the surface speed of the piece in question. Should it be found in this way that the machine at work on a steel piece only run, at a surface speed of about thirteen feet, it would be reasonable to conclude that the machine was running too slow, and the table in this way allows a ready judgment of the performance of the various tools.

Development of Formulæ and Explanation of Method.

Referring again to the problem quoted above of a lathe to turn cast-iron and steel from one-half of an inch to twelve inches

in diameter, we have found that the spindle of this machine must have a maximum and minimum speed.

To meet the varying conditions of intermediate diameters, the lathe will be constructed to give a certain number of speeds. The lathe, probably, will be back-geared and have a four, five or six step cone.

In a correct design these various speeds must have a fixed relation towards each other. For reasons often explained and given these various speeds must form a geometrical progression, and the problem briefly stated is this: "The obtainable number of speeds (the slowest and fastest being given) are to be proportioned in such a manner that they will form among themselves a geometrical progression." The ratio of the gearing is also to be found.

According to Trautwine, page 36, a geometrical progression in a series of numbers is a progressive increase or decrease in each successive number by the same multiplier or divisor at each step, as 3, 9, 27, 81, etc.

REVOL. PER MIN.	DIAMETER ¼	⅜	½	⅝	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—	—	—	—	10.79	11.79	12.76
20	—	—	—	—	—	—	—	—	—	10.47	11.78	13.08	14.39	15.71	17.02
25	—	—	—	—	—	—	—	—	11.45	13.09	14.72	16.36	17.99	19.63	21.27
30	—	—	—	—	—	—	—	11.78	13.74	15.70	17.67	19.63	21.59	23.56	25.52
35	—	—	—	—	—	—	11.45	13.74	16.03	18.32	20.61	22.90	25.19	27.49	29.77
40	—	—	—	—	—	10.47	13.08	15.72	18.32	20.94	23.56	26.17	28.79	31.42	34.03
45	—	—	—	—	—	11.78	14.72	17.69	20.61	23.56	26.52	29.44	32.39	35.34	38.28
50	—	—	—	—	—	13.09	16.36	19.65	22.90	26.18	29.45	32.72	35.99	39.27	42.54
55	—	—	—	—	10.79	14.39	17.99	21.61	25.19	28.79	32.40	35.99	39.59	43.20	46.79
60	—	—	—	—	11.77	15.70	19.63	23.58	27.48	31.41	35.44	39.26	43.19	47.12	51.05
65	—	—	—	10.63	12.75	17.01	21.26	25.54	29.77	34.03	38.38	42.53	46.79	51.05	55.30
70	—	—	—	11.45	13.74	18.32	22.90	27.62	32.07	36.65	41.33	45.80	50.39	54.98	59.56
75	—	—	—	12.27	14.72	19.63	24.54	29.49	34.36	39.27	44.27	49.08	53.99	58.90	63.81
80	—	—	10.47	13.08	15.70	20.94	26.17	31.45	36.65	41.88	47.22	52.35	57.59	62.83	68.07
85	—	—	11.12	13.90	16.68	22.25	27.81	33.41	38.94	44.50	50.16	55.62	61.19	66.76	72.32
90	—	—	11.78	14.72	17.66	23.56	29.44	35.38	41.23	47.12	53.11	58.89	64.79	70.68	76.57
95	—	—	12.48	15.64	18.64	24.87	31.28	37.34	43.52	49.74	56.05	62.16	68.39	74.61	82.83
100	—	—	13.09	16.46	19.62	26.18	32.92	39.33	45.81	52.36	59.00	65.46	71.99	78.54	
110	—	10.79	14.39	18.09	21.59	24.79	36.19	43.25	50.39	57.59	64.89	72.00	79.19	86.39	
120	—	11.77	15.73	19.73	23.55	31.46	39.46	47.18	54.97	62.83	70.78	78.55			
130	—	12.75	17.01	21.35	25.51	34.03	42.71	51.11	59.65	68.06	76.57	85.09			
140	—	13.73	18.37	22.98	27.47	36.65	45.96	55.03	64.14	73.30	82.56				
150	—	14.72	19.63	24.61	29.44	39.27	49.22	58.96	68.72	78.54					
160	10.47	15.70	20.94	26.23	31.40	41.88	52.47	62.89	73.30	83.77					
170	11.12	16.68	22.25	27.86	33.36	44.50	55.72	66.81	77.88						
180	11.78	17.66	23.56	29.48	35.32	47.12	58.97	70.74	82.46						
190	12.43	18.64	24.87	31.11	37.29	49.74	62.22	74.67							
200	13.09	19.62	26.18	32.74	39.25	52.36	65.45	78.64							
210	13.79	20.60	27.48	34.36	41.21	54.97	68.72	82.52							
220	14.39	21.59	28.79	35.94	43.18	57.59	71.98								
230	15.05	22.57	30.10	37.61	45.15	60.21	75.26								
240	15.70	23.55	31.41	39.74	47.11	62.83	78.53								
250	16.36	24.53	32.72	40.87	49.07	65.45	81.81								
260	17.06	25.50	34.13	42.50	51.01	68.26									
270	17.72	26.49	35.44	44.14	52.98	70.88									
280	18.37	27.47	36.75	45.77	54.94	73.50									
290	19.03	28.45	38.06	47.41	56.90	76.12									
300	19.68	29.43	39.37	49.04	58.86	78.74									
310	20.33	30.41	40.67	50.68	60.83	81.35									
320	20.99	31.39	41.98	52.31	62.79										
330	21.64	32.37	43.29	53.95	64.75										
340	22.30	33.36	44.60	55.58	66.72										
350	22.95	34.34	45.90	57.22	68.68										
375	24.59	36.82	49.18	65.40	73.64										
400	26.22	39.25	52.45	73.57	78.50										
450	29.49	44.20	58.59												
500	32.76	49.16	65.53												

REVOL. PER MIN.	DIAMETER 3½	3¾	4	4½	5	5½	6	6½	7	7½	8	9	10	11	12
5	—	—	—	—	—	—	—	—	—	—	10.47	11.96	13.09	14.40	15.71
8	—	—	—	—	10.47	11.52	12.56	13.61	14.66	15.71	16.75	20.51	20.94	23.04	25.05
10	—	—	10.95	11.79	13.09	14.99	15.71	17.02	18.32	19.63	20.94	23.89	26.18	28.80	31.41
15	13.75	14.73	16.43	17.68	19.63	21.60	23.56	25.52	27.49	29.45	31.43	35.84	39.27	43.19	47.12
20	18.33	19.64	21.91	23.58	26.18	28.80	31.42	34.03	36.65	39.26	41.91	47.79	52.36	57.59	62.83
25	22.92	24.55	27.39	29.47	32.72	36.00	39.27	42.54	45.81	49.08	52.38	59.74	65.45	71.99	78.54
30	27.50	29.46	32.87	34.37	39.27	43.20	47.12	51.05	54.97	58.90	62.85	71.68	79.54		
35	32.08	34.36	38.34	41.26	45.81	50.40	55.00	59.55	64.14	68.72	73.32	83.63			
40	36.66	39.27	43.82	47.16	52.36	57.60	62.83	68.06	73.30	78.53	83.79				
45	41.25	44.18	49.30	53.05	58.90	64.80	70.68	76.57	82.46						
50	45.83	49.09	54.78	58.95	65.45	72.00	78.54								
55	50.42	55.00	60.26	64.84	71.99	79.20									
60	55.00	59.91	65.73	70.73	78.55										
65	59.58	64.82	71.21	76.63											
70	64.16	68.72	76.69	82.52											
75	68.75	73.64	82.16												
80	73.33	78.64													
85	77.91														
90	81.50														

SURFACE SPEEDS IN FEET PER MIN.

FIG. 2.

To treat the problem algebraically let there be

n = number of attainable speeds,
a = slowest speed.
b = fastest speed.
d = number of speeds of cone.
n-1 = number of steps or intervals in the progression of attainable speeds.
f = ratio of one step or factor, wherewith to multiply any speed to get the next higher.

Algebraically expressed, the various speeds, therefore, form the following series:

$$a, af, af^2, af^3, af^4 \ldots\ldots\ldots af^{n-2}, af^{n-1}.$$

The last, or fastest speed, is expressed by $f^{n-1}a$ and also by the letter b. Therefore, $af^{n-1} = b$, or

$$f^{n-1} = \frac{b}{a}, \text{ and therefore}$$

$$f = \sqrt[n-1]{\frac{b}{a}}$$

Suppose we have, as an example, a lathe with a four speed cone, triple geared. In this case we would have four speeds for the cone, four more speeds for the cone with back-gears, and still four more speeds of cone with triple-gears; therefore, in all twelve speeds. Assuming "a" as the slowest speed in this case, "b" would be expressed by, a f^{11}, and the series, therefore, beginning with the fastest speed would run.

$$af^{11}, af^{10}, af^9, \text{etc.}, af^3, af^2, af, a.$$

The four fastest speeds, which are obtainable by means of the cone alone would be,

$$af^{11}, af^{10}, af^9, af^8.$$

"d" = the number of speeds of cone, which in this case is four.

Dividing each of the four members of the series above given by f^4, we obtain the following series:

$$af^7, af^6, af^5, af^4,$$

as the speeds of cone with back-gears.

Again dividing the series of speeds of the cone,

$$af^{11}, \text{ to } af^8 \text{ by } f^4 \times f^4 = f^8,$$

we obtain the series,

$$af^3, af^2, af, a$$

as the series of speeds of cone with triple gears.

We have, therefore, in this way accounted for all the twelve speeds that the combination given is capable of, and it is now very evident that the ratio of the back-gears must be f^d, in this case f^4, ("d" being equal to 4,) and the ratio of triple-gears f^{2d}, or in this case f^8.

By carrying this example still further, we would find that the ratio of quadruple-gears would be f^{3d}.

We can summarize the proceeding and put it in a more convenient form for calculation by writing:

lg of ratio of back-gears $= d \lg f$
lg " " " triple-gears $= 2d \lg f$
lg " " " quadruple-gears $= 3d \lg f$

The problem with this consideration, therefore, is solved. An example will be worked out below.

We will now consider the complication of the problem which very often occurs. Should the overhead work of the drive in consideration have two speeds, then we will obtain double the number of available speeds for the machine, and this number of speeds may be expressed by 2 n, in order to conform to the nomenclature used above. This modified problem is treated

just as the problem above, and the series of speeds is found as in the first case, and we have as a factor

$$f = \sqrt[2n-1]{\frac{b}{a}}$$

We must consider now that one-half the obtained speeds are due to the first over-head speed, the other half to the second.

In writing the odd number of speeds found in one column and the even number of speeds in another, we obtain the following two series:

$a, af^2, af^4 \ldots\ldots\ldots\ldots af^{2n-4}, af^{2n-2}$

$af, af^3, af^5 \ldots\ldots\ldots\ldots af^{2n-3}, af^{2n-1}$

In examining these two series we will find, that they are both geometrical progressions, and furthermore, that each progression has the same factor, and calling this factor, f_1, we have

$$f_1 = f^2$$

and the ratio of the two counter-shaft speeds is equal to f, because to obtain any speed in the second series we multiply the corresponding speed in the first series by f. The two series n our case are due to the two over-head work speeds. We need o concern ourselves with only one, but either one of the two series, and without going again through the explanation for the first case, it is very evident that we will arrive at the following conclusions:

lg of ratio of back-gears $= d \lg f_1$

" " " " triple-gears $= 2d \lg f_1$

" " " " quadruple gears $= 3d \lg f_1$

Having in this way obtained all the desired speeds and the ratios of the gears, it is a simple matter for the designer to determine the actual diameters of the various steps for the cone and for the gears. To do so he has at his disposal various methods, which need not be explained here. The main thing for him to have is a geometrical progression of speeds, as a foundation for his design.

Example 1. A Triple Geared Lathe.

Suppose the following example to be given:

Proportion the speeds and find the gear ratio of a six step cone, triple geared.

Slowest speed, .75 revolutions per minute.

Fastest speed, 117 revolutions per minute.

This example of a six-step cone, triple-geared, will give us eighteen available speeds,

$$n = 18$$
$$n\text{-}1 = 17$$
$$a = .75$$
$$b = 117 \text{ therefore,}$$

$$f = \sqrt[17]{\frac{117}{.75}} = \sqrt[17]{156}$$

The slowest speed being given, we multiply it by the factor f to obtain the next higher, and this one in turn is again multiplied by the factor f, and so on until we have reached the highest speed—b. The 17th root of 156 is easiest found by the use of logarithms.

We have

$$\lg 156 = 2.1931246$$
$$\lg f = 1/17 \lg 156 = 0.129007329$$
$$f = 1.3458$$

Now we follow out the multiplication by finding the logarithm of .75, the slowest speed, adding to it the logarithm of the factor f to obtain the logarithm of the next higher speed, and adding the logarithm of factor f to the sum of these two logarithms will give us the logarithm of the next higher speed. By looking up the numbers for these logarithms we find these speeds to be 1.009 and 1.358. The complete calculation is given below:

$$\lg .75 = 0.8750613 - 1$$
$$\text{" } f = 0.129007329$$
$$0.004068629 = \lg 1.009 -$$
$$0.129007329$$
$$0.133075958 = \lg 1.358 -$$
$$0.129007329$$
$$0.262083287 = \lg 1.828 -$$
$$0.129007329$$
$$0.391090616 = \lg 2.461 -$$
$$0.129007329$$
$$0.520097945 = \lg 3.312 -$$

REV. PER MIN.	DIAMETER 1" 12	13	14	15	16	17	18	19	20	22	2" 24	26	28	30	32
.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.2	—	—	—	—	—	—	—	—	—	—	—	—	—	9.42	10.05
1.4	—	—	—	—	—	—	—	—	—	—	—	—	10.26	11.00	11.72
1.6	—	—	—	—	—	—	—	—	—	—	10.08	10.89	11.72	12.56	13.40
1.8	—	—	—	—	—	—	—	—	—	10.37	11.31	12.25	13.19	14.13	15.07
2.	—	—	—	—	—	—	—	9.95	10.47	11.52	12.56	13.61	14.66	15.71	16.75
2.25	—	—	—	—	—	10.01	10.60	11.18	11.78	12.96	14.14	15.31	16.49	17.67	18.84
2.5	—	—	—	9.81	10.47	11.12	11.78	12.42	13.09	14.40	15.76	17.02	18.33	19.63	20.94
2.75	—	—	10.08	10.80	11.51	12.23	12.95	13.66	14.40	15.84	17.28	18.72	20.16	21.60	23.03
3.	—	10.21	10.99	11.78	12.56	13.35	14.13	14.89	15.71	17.28	18.85	20.42	21.99	23.56	25.12
3.5	10.50	11.91	12.83	13.74	14.66	15.57	16.49	17.36	18.33	20.16	21.99	23.85	25.66	27.49	29.31
4.	12.57	13.61	14.16	15.70	16.75	17.80	18.85	19.84	20.94	23.04	25.14	27.26	29.32	31.41	33.50
4.5	14.14	15.31	16.49	17.67	18.84	20.02	21.20	22.31	23.56	25.92	28.28	30.66	32.98	35.34	37.69
5.	15.71	17.02	18.33	19.63	20.94	22.25	23.56	24.78	26.18	28.79	31.42	34.06	36.65	39.27	41.88
5.5	17.28	18.72	20.16	21.60	23.03	24.47	25.91	27.25	28.80	31.67	34.56	37.47	40.32	43.20	46.66
6.	18.85	20.42	21.99	23.56	25.13	26.70	28.27	29.72	31.42	34.55	37.70	40.87	43.98	47.12	50.25
6.5	20.42	22.12	23.82	25.52	27.22	28.92	30.63	32.20	34.03	37.43	40.84	44.27	47.65	51.05	54.44
7.	21.94	23.82	25.66	27.49	29.31	31.15	32.98	34.67	36.65	40.31	43.99	47.68	51.31	54.98	58.63
7.5	23.56	25.53	27.49	29.45	31.41	33.37	35.34	37.14	39.27	43.19	47.13	51.08	54.98	58.90	62.82
8.	25.13	27.23	29.32	31.41	33.50	35.60	37.69	39.61	41.89	46.07	50.27	54.48	58.64	62.83	67.01
8.5	26.70	28.93	31.15	33.38	35.60	37.82	40.05	42.08	44.51	48.94	53.41	57.89	62.31	66.76	71.19
9.	28.28	30.63	32.99	35.34	37.69	40.05	42.41	44.56	47.12	51.82	56.55	61.29	65.97	70.68	75.88
9.5	29.85	32.33	34.82	37.30	39.78	42.27	44.76	47.03	49.74	54.70	59.69	64.69	69.64	74.61	79.57
10	31.42	34.03	36.65	39.26	41.88	44.51	47.13	49.50	52.36	57.58	62.84	68.10	73.30	78.54	
11	34.56	37.44	40.32	43.19	46.07	48.97	51.85	54.48	57.60	63.34	69.12	74.91	80.63		
12	37.70	40.84	43.98	47.12	50.26	53.43	56.57	59.45	62.83	69.10	75.40	81.71			
13	40.84	44.24	47.65	51.04	54.44	57.89	61.29	64.42	68.07	74.86	81.68				
14	43.98	47.65	51.31	54.97	58.63	62.35	66.01	69.40	73.30	80.62					
15	47.03	51.05	54.98	58.90	62.82	66.81	70.73	74.37	78.54						
16	50.17	54.45	58.64	62.82	67.01	71.27	75.45	79.35	83.78						
17	53.31	57.86	62.31	66.75	71.20	75.73	80.17	84.32							
18	56.45	61.26	65.97	70.68	75.39	80.19									
19	59.59	64.86	69.64	74.60	79.58										
20	62.73	66.27	73.30	78.53											

REV. PER MIN.	DIAMETER 3" 36	40	4" 44	48	52	5" 56	60	64	6" 68	72	7" 78	84	90	8" 96	10" 120
.5	—	—	—	—	—	—	—	—	—	—	10.21	10.09	11.78	12.56	15.70
.6	—	—	—	—	—	—	—	10.05	10.68	11.31	12.25	13.19	14.14	15.08	18.84
.7	—	—	—	—	—	10.26	10.99	11.72	12.46	13.19	14.29	15.39	16.49	17.59	21.99
.8	—	—	—	10.10	10.89	11.73	12.56	13.40	14.24	15.08	16.34	17.59	18.85	20.11	25.13
.9	—	—	10.37	11.31	12.25	13.19	14.13	15.07	16.02	16.96	18.38	19.79	21.20	22.62	28.27
1.	—	10.47	11.52	12.56	13.61	14.66	15.70	16.75	17.80	18.85	20.42	21.99	23.56	25.13	31.41
1.2	11.31	12.57	13.82	15.08	16.25	17.59	18.84	20.10	21.36	22.62	24.50	26.39	28.26	30.16	37.69
1.4	13.19	14.66	16.13	17.54	18.97	20.52	21.99	23.45	24.92	26.39	28.59	30.79	33.00	35.18	43.98
1.6	15.08	16.76	18.42	20.15	21.69	23.46	25.13	26.80	28.48	30.16	32.67	35.18	37.68	40.21	50.26
1.8	16.96	18.85	20.73	22.62	24.41	26.39	28.27	30.15	32.04	33.93	36.76	39.58	42.39	45.24	56.54
2.	18.85	20.94	23.04	25.13	27.14	29.32	31.41	33.50	35.60	37.70	40.84	43.98	47.13	50.26	62.83
2.25	21.20	23.56	25.92	28.27	30.54	32.99	35.34	37.69	40.05	42.41	45.94	49.78	53.01	56.55	70.69
2.5	23.56	26.18	28.79	31.41	33.94	36.65	39.27	41.88	44.51	47.12	51.05	54.98	58.89	62.83	78.55
2.75	25.92	28.80	31.67	34.56	37.35	40.32	43.29	46.06	48.96	51.83	56.15	60.47	64.80	69.11	86.41
3.	28.27	31.42	34.55	37.70	40.75	43.98	47.12	50.25	53.41	56.55	61.26	65.97	70.68	75.39	
3.5	32.98	36.65	40.31	43.99	46.96	51.31	54.98	58.63	62.31	65.97	71.47	76.97	82.47	87.98	
4.	37.70	41.89	46.07	50.27	53.76	58.64	62.83	67.00	71.21	75.40	81.68	87.96			
4.5	42.41	47.12	51.83	56.56	60.57	65.97	70.68	75.38	80.11	84.82					
5.	47.12	52.36	57.59	62.84	67.38	73.30	78.54	83.76							
5.5	51.83	55.60	63.35	69.12	74.18	80.63	86.39								
6.	56.54	62.83	69.11	75.41	80.99										
6.5	61.26	68.07	74.87	81.60											
7.	65.97	73.30	80.63												
7.5	70.68	78.54													
8.	75.39	83.78													
8.5	80.11														

SURFACE SPEEDS IN FEET PER MIN.

FIG. 3.

0.129007329

0.649105274 = lg 4.457 —
0.129007329

0.778112603 = lg 5.999 —
0.129007329

0.907119932 = lg 8.074 —
0.129007329

1.036127261 = lg 10.867 —
0.129007329

1.165134590 = lg 14.626 —
0.129007329

1.294141919 = lg 19.685 —
0.129007329

1.423149248 = lg 26.294 —
0.129007329

1.552156577 = lg 35.658 —
0.129007329

1.681163906 = lg 47.991 —
0.129007329

1.810171235 = lg 64.591 —
0.129007329

1.939178564 = lg 86.931 —
0.129007329

2.068185893 = lg 117.—

Now for example, the number of speeds of cone (d) = 6, and according to our formula, the logarithm of the ratio of the back-gears = d lg f, and the logarithm of ratio of the triple-gears = 2d lg f. Expressed in figures we have:

$$\lg f = 0.129007329$$
6 steps 6

$$0.774043974$$

Ratio of back-gears: 5.9435

$$12 \lg f = 1.548087948$$

Ratio of triple-gears: 35.325

Example 2.—Lathe with two Countershaft Speeds.

Suppose the following example is given:

Proportion the speeds and find the gear-ratio of a four-step cone, back-geared, two speeds to counter-shaft.

Slowest speed, twenty-five revolutions per minute,

Fastest speed, 500 revolutions per minute.

In this case

$$n = 16$$

$$f = \sqrt[15]{\frac{500}{25}} = \sqrt[15]{20}$$

$$\lg 20 = 1.3010300$$

$$\lg f = \frac{1}{15} \lg 20 = 0.08673533$$

$$f = 1.2210$$

In following out the calculation as shown in Example I., we obtain the following series of sixteen speeds:

1)25.—	5) 55.58	9)123.54	13)274.64
2)30.53	6) 67.86	10)150.85	14)335.35
3)37.28	7) 82.86	11)184.20	15)409.48
4)45.51	8)101.18	12)224.92	16)500.

Of these sixteen speeds, eight are due to one over-head work speed; the other eight are due to the second over-head work speed. We write the odd and even speeds in two series, as below:

First Series.	Second Series.
1) 25.	2) 30.58
3) 37.28	4) 45.51
5) 55.58	6) 67.86
7) 82.86	8)101.18
9)123.54	10)150.85
11)184.20	12)224.92
13)274.64	14)335.35
15)409.48	16)500.

In order to find the ratio of the back-gears we can use either one of these two series, and as explained above, $f_1 = f^2$. We therefore have

$$\lg f = 0.08673533$$
$$2$$

$$\lg f^2 = \lg f_1 = 0.17347066$$
4 steps 4

$$0.69388264$$

Ratio of back gears: 4.9418.

Ratio of counter-shaft speeds: f = 1.2210.

This method of geometrically proportioning speeds in machine drives, which has been explained at length, will be found, after one or two applications, a rather simple one. But its usefulness is not limited to the proportioning of speeds in machine drives, as it can also be applied to the proportioning of feeds.

Feeds for Machine Tools.

Before proceeding to apply this method to the geometrically proportioning of feeds in machines, a few remarks on feeds may not be out of place. By feeds are understood the advances of table, carriage or work in relation to the revolution of the machine spindle. Feeds may be expressed in inches per minute or inches per revolution of spindle. In a table given below, feeds for different machines are given in inches for one revolution per spindle. The mechanical values are given in inches and millimeters. This table is supposed to represent modern practice, but, of course, the figures given represent general experience, and special cases, no doubt, will often modify them considerably.

For—	Inches.	Millimeter.
Plain milling machines	.005 — .2	.127 — 5.08
Large plain milling machines	.010 — .3	.254 — 7.62
Universal milling machine	.003 — .2	.076 — 5.08
Large universal milling machine	.003 — .25	.076 — 6.35
Automatic gear cutter, small	.005 — .1	.127 — 2.54
(Backed-off cutter), large	.010 — .25	2.54 — 6.35
Drills (spindle-feed)	.004 — .02	.102 — .508
Planing machine (traverse feed)	.005 — .7	.127 —17.78
Slotting machine (feed of work)	.005 — .2	.127 — 5.08
Drilling long holes in spindles (per revolution of drill)	.003 — .01	.076 — .254
Lathes, feed for roughing	56 & 80	In turns per inch.
" " " finishing	112	Travel of carriage

UNIVERSAL GRINDING MACHINE.

Surface speed of emery-wheel, 4,000—7,000 feet per minute (1,220—2,133 m.)

Traverse of platen or wheel, 2″—32″ per minute (50—812 mm.); the fast feeds are for C. I., use water.

Surface speed of work on centers, 130—160 feet per minute (39.6—48.8 m.)

For internal work surface speed of emery-wheel (highest nominal speeds), with no allowance for slip of belt; lowest nominal speed about 40 per cent. less. Any speed between should be obtainable:

Dia. of Wheel.	Feet per Min.	Dia. of Wheel, mm.	M. per Min.
1⅝	3600	41	1100
1	2750	25	838
¾	2100	19	640
7-16	1450	11	442
¼	1100	6.3	335

SURFACE GRINDING MACHINE.

Surface speed of emery-wheel, 4,000—7000 feet per minute (1220—2133 m.)

Table speed per minute, 8—15 feet (2.44—4.57 m.)

Gross feed to one motion of platen, .005″—.2″ (.127—5.08 mm.)

Gross feed to one revolution of hand-wheel, .25″ (6.35 mm.)

PLANING MACHINE (SLOTTER).

Speed of table per minute, 20—25 feet (6.09—7.62 m.)

Return, 2 : 1; (4 : 1).

Problem 3.—The Feeds of a Milling Machine.

The problem of porportioning feeds of different machines, varies in each case although always embodying similar principles. It is, therefore, proposed to take a typical case and apply the method to the problem presented, and in this way explain the advantages of the particular treatment referred to in this article.

In Fig. 1 is given an outline drawing of a milling machine. The problem in this case will be the following:

Given the fastest and slowest feeds per one revolution of main spindle, proportion the obtainable feeds in such a manner that they will form a geometrical progression.

Cones D. E. as well as pulleys x and y can be transposed.

The main data with which we have to concern ourselves about this machine may be assumed to be as follows:

Lead screw, four threads per inch, single.

Advance of screw per one revolution, .25 inch.

Largest feed wanted .250 (equal to one revolution of screw).

Smallest feed wanted, .005 inch (equal to 1-50 revolution of screw.

For one revolution of screw shaft P (see Fig. 1) makes thirty revolutions.

For 1-50 revolution of screw, shaft P makes 30-50, equal .6 revolutions.

The ratio of revolutions between screw and shaft P is therefore in our example as 1 is to 30; that is, given the revolutions of shaft P we divide this number by 30 to obtain the revolutions of screw. The revolutions of the screw multiplied by the lead L (in this case equal to .25) gives the advance for given revolutions of P. Let there be:

V = Value of train from P to screw,
L = Lead of screw,
Pr = Revolutions of shaft P.
p = Advance or feed of screw per one revolution of spindle, expressed in inches.

We have,

$$p = \frac{PrL}{V} \qquad (1)$$

$$Pr = \frac{V\,p}{L} \qquad (2)$$

If now n equals the numbers of feeds wanted, we obtain for f, the factor wherewith to multiply each feed to get the next higher,

$$f = \sqrt[n-1]{\frac{b}{a}} \qquad 3)$$

in which b is the fastest and a the slowest speed of shaft P. That is,

Pr maximum = 30 = b
Pr maximum = .6 = a

Note: The method of obtaining this value for f has been explained at some length in the early part of the article to which the reader is referred.

The problem in our case stated that cones D and E, as well as pulleys x and y could be transposed.

The cones have four steps and transposing them gives us eight speeds. x and y being also transposable give, therefore, $2 \times 8 = 16$ speeds. The numerical value for f is therefore in our case,

$$f = \sqrt[16]{\frac{30}{.6}} = \sqrt[15]{50}$$

The maximum and the minimum speeds of shaft P per one revolution of spindle of machine, as well as the number of steps required being known, we readily obtain the geometrical series with the minimum speed of shaft P as a beginning and the maximum speed as the last step. The numerical values follow:—

lg 50 = 1.6989700
lg f = 1/15 lg 50 = 0.11326466
f = 1.2977

lg .6 = 0.7781513 − 1
0.11326466

0.89141596 − 1 = lg .77878 (2)
11326466

.00468062 = lg 1.0108 (3)
11326466

.11794528 = lg 1.3120 (4)
11326466

.23120994 = lg 1.7030 (5)
11326466

.34447460 = lg 2.2104 (6)
11326466

.45773926 = lg 2.8691 (7)
11326466

.57100392 = lg 3.7240 (8)
11326466

.68426858 = lg 4.8336 (9)
11326466

.79753324 = lg 6.2739 (10)
11326466

.91079790 = lg 8.1432 (11)
11326466

1.02406256 = lg 10 570 (12)
11326466

1.13732722 = lg 13.719 (13)
11326466

1.25059188 = lg 17.807 (14)
1136466

1.36385654 = lg 23.113 (15)
11326466

1.47712120 = lg 30. (16)

The value of p in our case (see Formula I.) becomes

$$p = \frac{Pr\,(.25)}{30} \text{ or } p = .0083\ Pr, \qquad (4)$$

in which Pr, the number of revolutions of shaft P has the different values found above:

By substituting these values of Pr, we obtain the following feeds, which are the feeds of the lead screw per one turn of machine spindle.

1) .6 × .0083 = .005 inches.	9) 4.83 × .0083 = .0400 inches
2) .78 × " = .0065	10) 6.23 × " = .0517
3) 1.01 × " = .0084	11) 8.14 × " = .0677
4) 1.31 × " = .0109	12) 10 57 × " = .0877
5) 1.70 × " = .0141	13) 13.72 × " = .1138
6) 2.21 × " = .0183	14) 17.81 × " = .1513
7) 2.87 × " = .0238	15) 23.11 × " = .1918
8) 3 72 × " = .0308	16) 30. × " = .2500

We now write the speeds found for shaft P in two columns, one containing the odd numbers and the other the even numbers, in this manner:

I.	II.
1) .6	2) .78
3) 1.01	4) 1.31
5) 1.70	6) 2.21
7) 2.87	8) 3.72
9) 4.83	10) 6.23
11) 8.14	12) 10.57
13) 13 72	14) 17.81
15) 23.11	16) 30.

The series of speeds in each column forms a geometrical progression, and we can assume that the speeds in the first column are due to the position of the pulleys x and y, as shown in the outline drawing, Figure I., and that the speeds in the second column are due to a reversed position of x and y. That is to say, the speeds in column II., are obtained after having changed y to x and x to y.

As these speeds in the second column are equal to the speeds in the first column multiplied by factor f, it follows that the two speeds of shaft R are to each other as 1 is to f. Assuming these two speeds to be m and n the proportion exists,

$$m : n :: 1 : f \quad (5)$$

Supposing x and y to represent the diameters of the respective pulleys it will be evident that

$$1 \times x = my$$

$$m = \frac{x}{y} \quad (6), \text{ and also}$$

$$1 \times y = n\,x, \text{ or}$$

$$n = \frac{y}{x} \quad (7)$$

Substituting the values (6) and (7) in Formula (5), we have

$$\frac{x}{y} : \frac{y}{x} :: 1 : f, \text{ or}$$

$$\frac{x}{y} f = \frac{y}{x} . 1$$

$$f = \frac{\frac{y}{x}}{\frac{x}{y}} = \frac{y}{x} \times \frac{y}{x} = \frac{y^2}{x^2}$$

$$f = \frac{y^2}{x^2} \quad (8)$$

The value of f being known we have in Formula (8) an expression of the relation the diameters of the pulleys x and y must bear to each other. Putting this formula into a more handy shape we find

$$f = \frac{y^2}{x^2}$$

$$y^2 = f\,x^2 \qquad\qquad x^2 = \frac{y^2}{f}$$

$$y = \sqrt{f\,x^2} \quad (9) \qquad\qquad x = \sqrt{\frac{y^2}{f}} \quad (10)$$

In using either (9) or (10) and assuming one diameter, the other one is easily found.

The remaining part of problem, that is to find the diameters of the cone, is now a simple matter, and several well known methods can be employed to that end.

* * *

AN AUTOMATIC HINGE MACHINE.

It appears at the present time that almost any article requiring to be produced in sufficient quantities to warrant the cost of special tools for its production, can be manufactured by the use of such appliances at a cost which is only a fraction of that which would be required where the usual method is followed that requires to any extent, the element of manual labor. A case in mind is the small hinges that are used on the little wooden boxes so popular with school children for keeping their pencils and other small treasures. The hinges used are quite minute, as it takes about 600 to weigh one pound, but they are perfectly formed and require the same essential operations in their manufacture as the larger forms made for doors, etc.

A firm in Brooklyn that makes a specialty of these school boxes, recently had a special automatic machine built by Mr. L.

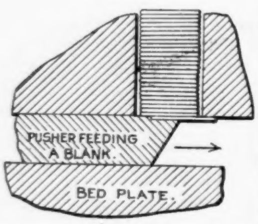


FIG. 2

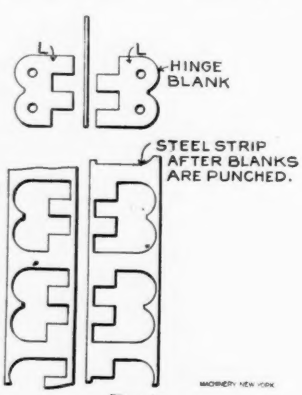


FIG. 3

T. Weiss, of that city, for the manufacture of these hinges, and we have been able to secure the photograph, reproduced in Fig. 1, and also a description of the working parts.

A visit to the shop where the machine was in operation found an ordinary Weilland and Osswald press with the hinge machine as an attachment, and as can be seen in the cut, it takes the place of the ordinary die-holder. The action of the machine is strictly automatic, the attendant having only to keep up the supply of steel strips and brass wire required for the hinges and to remove any imperfect ones that happen to be made through defects of the stock. Should such hinges be made and fail to leave the dies, an electrical device immediately throws out a clutch and stops the machine so that the mechanism will not jam.

While the writer was at the factory the machine was turning out perfectly formed hinges at the rate of 60 per minute or 36,000 per day of ten hours, but since then the speed has been increased to 60,000 per day. Even at this rate the manufacturer was endeavoring to increase the product, as he was behind in his orders, and was desirous of getting a stock ahead. When articles are being made in million lots, the magnitude of the number becomes apparent, as in this case with a product of 60,000 per day

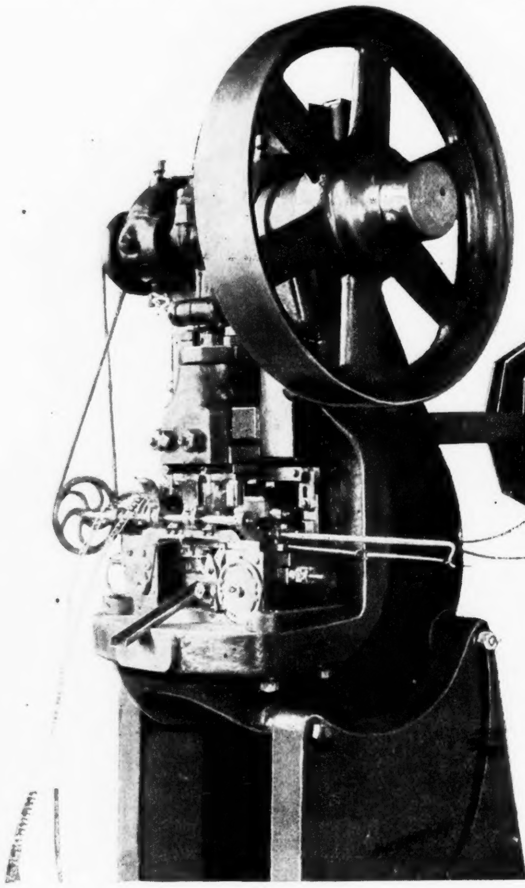


FIG. I. AUTOMATIC HINGE MACHINE.

nearly three weeks are required for the completion of that amount.

By referring to Fig. 1 the strips of Bessemer steel can be seen wound around the reel attached to the back of the press and passing through the machine to the front, where they appear in

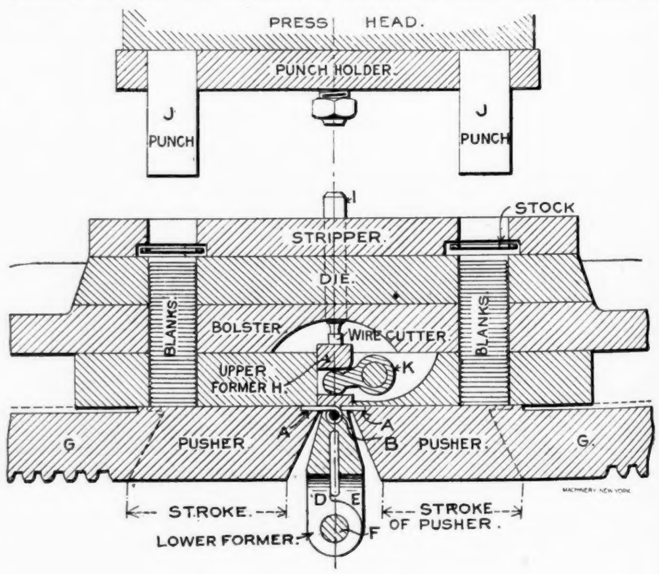


FIG. 4.

the perforated state. A brass wire is run through simultaneously and the three have the relative positions shown in the upper part of Fig. 3. The width of the steel is about ½″, the thickness about .015″, and the diameter of the wire is .042″.

The blanks are punched out of the shape shown in Fig. 3, the holes being punched at the previous stroke. The blanks fall into

the "wells," shown in Fig. 4, which also shows the ends of the stock in the slots between the stripper and die-plate. Simultaneously with the punching of the blanks, the "pushers," G G, shove a blank from each side into the formers shown at the center. As will be seen the lower former is in two parts, pivoted at F, and the upper former is controlled by the crank K. Now, when the two blanks are pushed into the formers, the ends curl around the wire B, and then the upper former and the jaws of the lower one which have been slightly open close tightly and thus "set" the hinge into its completed shape. At the same time the wire is cut and when the jaws open the cut wire feeds and pushes the completed hinge out wheie it falls into the small trough, shown in front. As before stated, if an imperfect hinge refuses to leave the dies, the machine is immediately stopped.

We have not attempted to show any but the essential features of the machine, but as will be seen from Fig. 1 there are many details that are absolutely essential to its successful operation and not the least is accuracy of workmanship. The little shop of Mr. Weiss has turned out some ingenious products, and we expect to be able to show some more of his interesting devices in the future.

* * *

ITEMS OF MECHANICAL INTEREST.

INTERCHANGEABLE FOUNDRY FLASKS.

A little shop in Newark is, and has been for many years, manufacturing foundry flasks for brass moulder's work on the plan of interchangeability. These flasks are accurately planed off at the junction of the cope and nowel and long pins provided that fit without shaking in reamed holes. The idea of accurateness and interchangeability is nothing particularly startling at this age, but, as applied to the ordinary moulder's flask it attracts more or less attention, as the notoriously slipshod methods of many foundries destroys any idea of closeness of fit on this much abused piece of foundry furniture. The most interesting feature of the business of this firm is, however, that their present product is interchangeable with that of forty or fifty years ago, and any owner of flasks made by them can now order missing copes or nowels to match those he purchased years ago, and get new ones to fit as well as the original mates. The templates of all the different flasks are carefully preserved in fireproof vaults so that in case of the destruction of the shop this branch of the business can be resumed without trouble. The value of interchangeability was evidently recognized by this early builder and applied to his product at a time when such practice was generally unknown.

We have carefully refrained from giving the present proprietor's name by his request as he evidently feared either a green-goods' game or possibly that his shop would be swamped by new orders.

A TROLLEY REPLACER.

Much valuable time is often lost in the unsuccessful attempts of trolley car conductors to replace the trolley pole and wheel in its proper position upon the line wire. The narrow face of the wheel requires the pole to be brought into exactly the right position beneath the wire before the rims of the wheel will pass up on each side in the proper position. The most difficult position for replacing the trolley is on curves and switches as the car is likely to be more or less out of alignment with the wire and these are places where the trolley is most likely to be displaced.

The device shown in Fig. 1, is a recent invention by a resident of Cleveland to obviate this trouble, and will instantly commend itself to the reader on account of its simplicity and practical utility. As clearly shown in the sketch, the wheel is much wider than the usual form and carries a central groove A for the wire, and on each side a helical groove B, B, which quickly carries the wire to the central groove when displaced. Thus the conductor does not require any special skill in replacing a displaced wheel, for if the wheel catches the wire in any part it is automatically carried to the center groove A.

Another useful device to prevent damage to cross-wires, etc., from misplaced trolley poles consists of a device which instantly checks the pole when it rises suddenly much above the proper level of the wire. The pole carries near the end a small drum which has many of the features of the well known spring shade roller so universally used. The drum has wound around it a cord which is fastened to the rear end of the car, the slack being taken up by a coil spring in the drum. The device only operates when the trolley leaves the track, then the sudden upward movement whirls the drum in rapid rotation, and thereby throws two little clicks or dogs out by the centrifugal force and locks them in slots provided for the purpose. The stoppage of

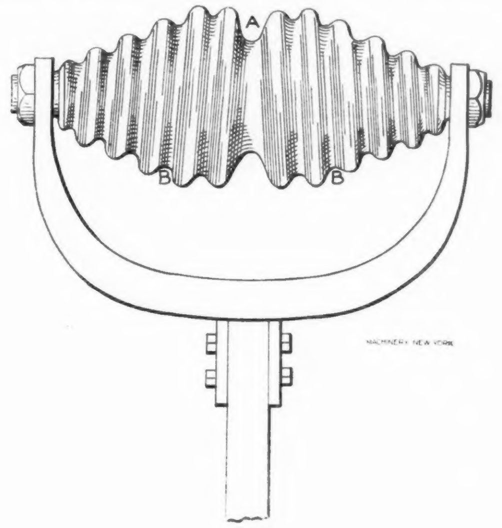


FIG. 1.

the drum holds the pole from rising much above the normal position. It will be observed that the action of the dogs in the drum only takes place with rapid movement, while in the household convenience they only operate under the opposite circumstances.

A DEVICE FOR INDICATOR CORDS.

Indicating a steam engine which is running at the rate of 300 to 400 revolutions a minute is an interesting operation, but it is not easy to hook and unhook the cord unless an old hand at the business. A little device to assist in this is shown in the accompanying sketch, taken from the London "Engineer." S, S, are two delicate, flat springs, fastened together at the top and suspended from above, as shown. At the lower end of one spring

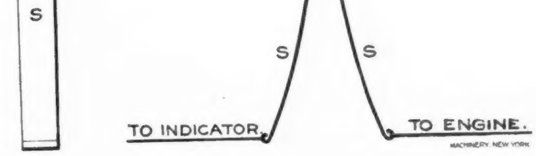


FIG. 2.

is the cord running to the indicator, and at the lower end of the other spring is the cord running to the reducing motion on the engine. A clip, C, encircles the two flat springs and can be slid up or down as desired. When it is slid up, the flexibility of the springs enables the indicator motion to run without unhooking the cord, while the indicator remains stationary. When the clip is moved down, however, the springs are brought together and held firmly in place so that both cords, and the indicator drum, move in unison with the reducing motion.

* * *

When you are reading and appreciating the shop kinks and bright notes contributed by the other fellow, don't forget some that you know of that will be read with interest, if you only give the editor a chance to have them printed.

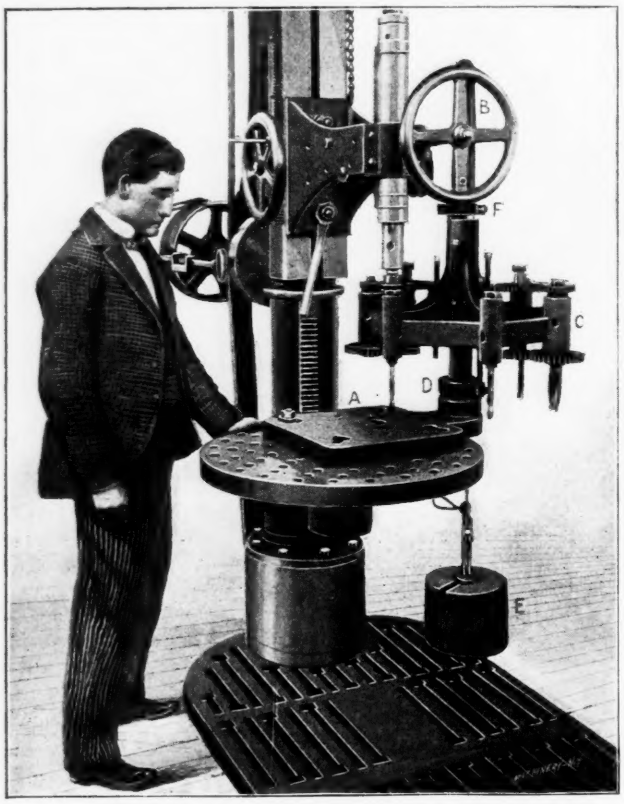
A TURRET DRILLING ATTACHMENT.

OBERLIN SMITH.

I am reminded by the article upon a turret drill in the January issue of MACHINERY, page 160, of a device of this kind which I designed and built in the year 1882, having used it at intervals since that time, for various kinds of jig work, where a quantity of duplicate pieces was required.

The principle of this device seems to be exactly the same as that shown in the recent article referred to; excepting that the vertical stud, upon which the turret revolves, is mounted in a base plate, which lies upon and is bolted to the table of the drill-press, instead of the stud being attached to the drill-press head above, as in the more recent machine. The latter construction, however, was considered at the time, but was not adopted in practice, because not so well adapted to the interchangeability of various turrets and drill-presses.

In the picture shown herewith, which has been taken from a photograph, the turret in question is mounted upon an ordinary type of medium sized drill-press. As will be seen, it consists mainly of a base plate, A, about 2" thick, with a heavy stud or post, B, rising some 36" therefrom, and a long-hubbed six-spindle turret, C, sliding and revolving thereupon, also long set-



DRILL PRESS WITH TURRET ATTACHMENT.

screws with lock-nuts, one for each spindle, forming respectively down-stop gauges for depth of work. The screw pertaining to the drill happening to be in action at any particular operation, strikes a projecting lug upon a collar, D, mounted upon the main stud. A composite balance-weight, E, hangs on a rope passing up through a longitudinal groove in the stud, over a pulley at the top and down a groove at the other side, where it is attached to a collar swivelled inside the turret hub.

Some of the spindles are shown without gears, but carrying small drills to be rotated at the same speed as the drill-press spindle; others are shown back-geared, with change-gears at the upper end which enable them to be revolved at any desired speed, without varying the revolutions per minute of the drill-press. If desired, any one of the back-gear shafts can be removed by taking off a nut and dropping it from its housing, in which case a geared spindle can be run as a non-geared one for small drills. When geared they can be used either for large drills, counter-sinkers, counter-boring tools, rose-bits, reamers, etc. With another attachment, not shown in the picture, consisting of a small train of reversing gears, any spindle can be used also for tapping.

In operation the whole turret with its tools is slightly overbalanced, by putting on the proper weights below at E, so that it will rise against the upper collar, F, shown on the stud. In this position the upper end of each turret spindle will strike a conical-ended chuck projecting from the drill-press spindle and automatically depress the turret, as it is swung into position. When the spindles are in the same axial line, the turret will rise and the two spindles will engage for driving.

Thus the indexing is performed by catching hold of the turret between spindles and slightly depressing it to disengage the clutch-like driver, with the same motion swinging it around one-sixth of a revolution (six happening to be the number of spindles in this particular turret) with the effect of engaging the next spindle as above described. To do all this, it is not necessary to stop the drill-press, or change the height of its spindle—which is run up against a stop.

The feeding is done with the ordinary drill-press feed, the turret sliding down upon the stud by the pressure thereof until the particular gauging-screw then in use strikes home. After this the quick-return device of the drill-press allows everything to rise rapidly to its former position. The jig, with its contained work, is then slid to another position for the next drill; or, it remains for a second operation upon the same hole, should such be needed.

This machine has also proved very useful for rough work without any jigs, wherein the drilled holes were located by counter-sinks or by cored holes. In such case the down-stop set-screws are not needed.

* * *

PROPORTIONS FOR WRENCHES.

RETSEL.

I have attempted to gather such published information as was available upon the subject of open-end wrenches, and submit herewith a few sketches showing what has been found. So far as I am able to determine, the only books alluding to the subject of wrenches are the following:

Unwin's Machine Design, Vol. 1, page 155.

D. A. Low's Pocket Book for Mechanical Engineers, page 373.

Meyer's Lessons in Mechanical Drawing and Machine Design, section 4, page 105.

Richards's Machine Design, page 131.

The only proportions proposed by Unwin are that the length of the wrench be from 15 to 18 times the diameter of the bolt, that the thickness of the jaws be 6-10 the diameter, and the thickness of the handle 4-10 the diameter. The width of the handle is to be equal to the diameter at a point about 1-3d the distance from the end.

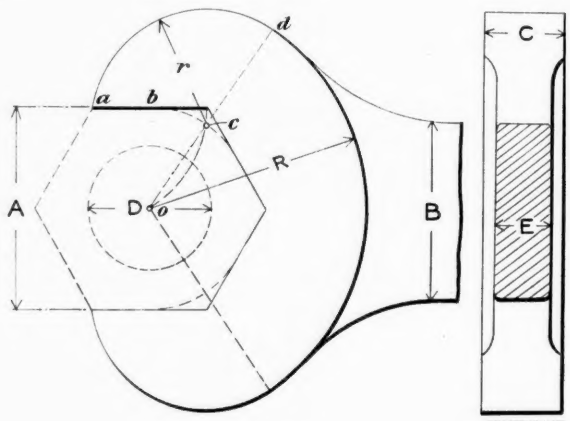


FIG. 1.

Low proposes the dimensions and construction for the jaws shown in Fig. 1, where

$A = 1\frac{1}{2} D + \frac{1}{8}''$; $B = \frac{5}{8}A + \frac{3}{8}''$; $C = \frac{1}{4}A + \frac{1}{4}''$; $E = \frac{1}{8}A + \frac{1}{4}''$,

The taper of the handle is to be 1 in 48, the length of the handle $8A + 2''$, and the construction of the jaws will be evident from the sketch. The circle D, equal to the diameter of the bolt, is first drawn, and the hexagon representing the nut is constructed. Then with a as a center and aO as a radius, describe the arc shown, and with O as a center and Ob as a radius, describe an arc cutting the first one at c. Through points O and c draw the line Od, the point d determining the length of the arc ad drawn with a radius r equal to the distance from c to a. The curve is continuad with the point O as a center with a radius R equal to Od.

Meyer's construction calls for a length of handle equal to 15 times the diameter of the bolt, a thickness of jaws of ¾ diameter and a thickness of handle of ⅜ diameter. The method of laying out the jaws and other dimensions of the wrench will be clear from the sketch.

The construction recommended by Richards is illustrated in Fig. 3. The arc b, b′ is drawn tangent to the sides of the nut with

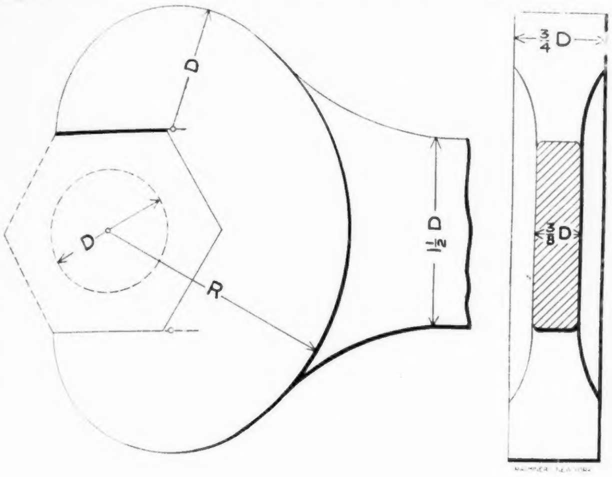


FIG. 2.

the point O as a center, and the line Od is drawn at an angle of 45 degrees with the center-line of the wrench. This gives the center c from which to strike the arc ad. The arc from d to d′ is drawn with a center at the left of the center O, which is a weaker construction than that used in the other two cases. The handle, however, is made wider, so as to strengthen the back of the jaws.

All of these designs are entirely empirical and it is doubtful whether any calculations could be made upon the strength and proportions of wrenches that would be of much, if any, value. It would be very easy to proportion the handle so that it would sustain a certain pull at the end and to proportion the jaws to bear the stress due to the pull on the handle without breaking and no more. Such methods, however, would be the height of folly, for no designer can estimate how much strain will be put on the handle, whether it will be used with ten feet of pipe on the end

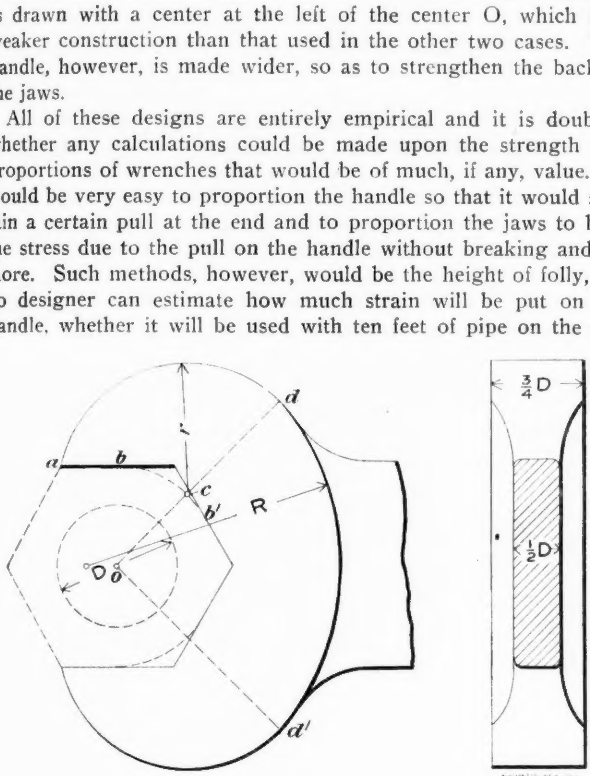


FIG. 3.

or not, nor how often the wrench will be made to fill the place and duties of a sledge hammer. The jaws of a wrench, moreover, should not be designed for breaking strength. It is stiffness that is wanted and a wrench that lacks this is one of the greatest nuisances that can exist around a shop, as battered bolt heads and nuts will testify.

As far as the proportions for the jaws are concerned, I should recommend that the designer use any of the constructions shown above, as may best suit his fancy.

When it comes to the length of the handle, however, a brief theoretical consideration may not come amiss and I should like to make a plea for the man who uses a piece of pipe on the end of a wrench, if he does so discriminately, in spite of the fact that he is usually condemned as a destructive agent.

The following table explains itself. The third column shows the pulls required on the end of a wrench 15 times the diameter of the bolt to produce the stresses of the second column, which are on the very moderate basis of 5,000 pounds per square inch. Column 5 shows the probable pulls required to break the bolts, producing the stresses given in the fourth column.

Diameter Bolt.	Safe Load on Bolt.	Pull required on Wrench.	Breaking Strength of Bolt.	Pull required on Wrench.
½	580	7	5,800	71
¾	1,410	17	14,000	171
1	2,620	32	25,000	305
1½	6,140	75	56,000	683
2	10,900	133	95,000	1,158
2½	17,730	216	150,000	1,829
3	26,000	316	213,000	2,597

The values for the third and fifth columns were computed from Unwin's formula, $P = 82\,Q$, where P is the stress in the bolt and Q is the pull exerted by the workman. The values given by this formula seem to me to be entirely too small and this conclusion would appear to be justified from the fact that Unwin derives his formula with the assumption that the coefficient of friction is 0.15. As a matter of fact, the coefficient of friction increases with the pressure and when the pressure reaches the amount that must sometimes be met with in screwing up bolts or nuts the frictional resistance must be larger than allowed.

Assuming, however, that his values are correct, it needs but a brief study of the table to show that a workman can safely use a wrench longer than 15 times the diameter of the screw for large size bolts and for the largest sizes he will want an extra long handle and some help on the end of it.

In making large wrenches, my suggestions are to so shape the handle that a pipe can be put on the end if necessary and provide a hole in the end of the handle of the largest sizes in which a tackle-block can be hooked; make the jaws of machine steel instead of wrought iron so that they will be as stiff as possible; and if buying wrenches, instead of making them, do not have the larger sizes case-hardened. They are liable to be too brittle for the work they have to do, or that may be done upon them.

* * *

SET-SCREWS.

Why is it that pulleys which are held on their shafts by set-screws give so much trouble by working loose? If the pulleys are a snug drive-fit on the shaft, as they usually are not, owing to the difficulty of putting them in place, set-screws will generally give good satisfaction, unless they are actually too small for the work they have to do. When the pulleys are loose on the shaft, however, there is every opportunity for them to work loose. In Fig. 2 is represented the hub of a pulley fastened to a shaft by a set-screw. The shaft is a loose fit in the hub, and it

FIG. 1.

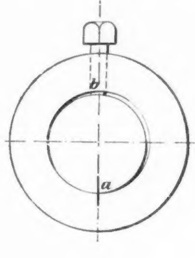


FIG. 2.

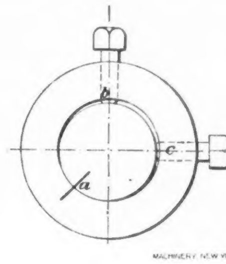


FIG. 3.

will be seen that it bears at two points only—at the bottom, a, and at the point of the set-screw, b. Points a and b are diametrically opposite each other, and the condition is about as shown in Fig. 1, which represents a disk like a coin or a piece of cardboard held between the points of two pencils. For unsteadiness and liability to wabble this arrangement is, perhaps, about as good as could be devised; and when the wabble occurs between a shaft and pulley hub, it will not take long for the set-screw to wear a large recess in the shaft and to work loose. In Fig. 3 is shown the advantage of two set-screws for a loose shaft, when placed at an angle with one another. They give a three-point bearing at a, b and c, which is much more secure.

* * *

Nickel steel is being tried with much success as a material for marine engines and boilers. Owing to its ability to resist the action of salt water it is found to be superior to other kinds of steel for marine construction. Hollow shafts in the ocean "greyhounds" are found to be much stronger when made of this alloy than when made of any other kinds of steel.

FAMILIAR SUBJECTS IN MECHANICS.—2.

SHAFTING.

SAMUEL WEBBER.

I have spoken in a recent article on "Cone Pulleys," of the continual recurrence in mechanical papers of questions often answered, but always arising again, as a new set of young readers come into the shops and are in search of general information. Among these questions, and appearing almost regularly, annually, in some paper or another, is the one, "How large a shaft will transmit a given number of horse power with safety?" or inversely, "How many horse power will such a shaft transmit, at a given velocity?"

The first of these questions is often answered by the following formula:

$$\text{Diam.} = \sqrt[3]{\frac{\text{HP.} \times 125}{\text{R. P. M.}}}$$

or for the inversed question,

$$\text{HP.} = \frac{\text{Diam.}^3 \times \text{R. P. M.}}{125.}$$

There is no objection to these answers, except that in very many cases, they call for a much larger diameter of shaft, than is absolutely necessary to transmit the power, or even to resist any transverse strain, which in the case of the first lengths of shafting, on which the pull of a main belt, or the thrust of gears comes, is fully as important a consideration to be provided for, as the simple amount of power to be transmitted. The "factor of safety," allowed by this formula is about 19 1-2 to 1, and this, while not objectionable in the case of heavy or sudden strains, seems to be rather larger than is really necessary, and it may be of interest to recall the data and conclusions of the late Jas. B. Francis, the eminent engineer of Lowell, who in 1867 published in the "Journal of the Franklin Institute," a paper giving the results of a series of trials and experiments, which he had made at the request of the Merrimac Manufacturing Co.

I will not attempt to follow out Mr. Francis' reasoning, but simply condense his experiments by saying, that after a long series of them, and an examination of all the records of tests of the breaking strain of wrought iron and steel, made by the English and U. S. Governments, as well as by many eminent engineers in private life, he assumed as a safe basis for the breaking strain of these materials—

Wrought Iron..................50,000 lbs. per sq. inch.
Steel ....80,000 lbs. per sq. inch.

These figures are below the average of his experiments, and he adopted them as a safe basis for calculation, and from it he deduced the formula

$$\text{Diam.} = \sqrt[3]{\frac{100 \times \text{HP.}}{\text{R. P. M.}}}$$

for wrought iron, which gave a factor of safety, of 15.58, above the breaking strain, and the same diameter gave for steel a factor of 24.92.

The formula for wrought iron, reversed, reads,

$$\text{HP.} = \frac{\text{D}^3 \times \text{R. P. M.}}{100}$$

This, however, Mr. Francis reduced to

$$\text{HP.} = \frac{\text{D}^3 \times \text{R. P. M.}}{50}$$

or a factor of safety of 7.79, for shafts not liable to transverse strain and simply transmitting power.

Attempts were made about the time of Mr. Francis' experiments, at the mills of the Merrimac Co., and other places in Lowell to reduce the power consumed by shafting, by the use of light steel shafts, adopting the factor of safety of 7.79, and the corresponding formula of

$$\text{Diam.} = \sqrt[3]{\frac{31.25 \times \text{HP.}}{\text{R. P. M.}}}$$

but these, though I do not recall the instance of any actual fractures, were so light and elastic, as to require "fly wheels" to ensure steady motion, and the use of such very light shafting has since been practically abandoned, very little shafting being now put up, less than from 1⅞ to 2 inches diameter, except for short counters, where smaller sizes are often adopted, especially when the distance between bearings is short. As mills and factories are generally constructed, the distance between bearings is usually from 8 to 10 ft., and a heavy pull in the center of 10 foot length will spring even a 2 inch shaft, so as to make unnecessary friction in its bearings.

The writer remembers a rather singular incident, in power-testing a number of years ago, which did not show friction in the bearings, but which showed a curious case of heating of the shaft. He was called on to weigh the power of a worsted spinning frame, driven by a belt running from a (2⅛ inch) shaft, in the centre of a 10 foot bay.

As the shaft was in the center of the room, and the pulleys on the frame were at the outside, next the windows, to keep the belts out of the middle of the room, the belt was taken across the room horizontally, and then over a pair of "Gallows pulleys," and down to the frame. As the power had to pass through the dynamometer, before reaching the frame, it was necessary to change the angle of the "Gallows pulleys," and to throw the belt off to do so. This was easily done with a "belt pole," but when it came to putting it on again, the writer had to get up on a "horse" and do it by hand, and he found the shaft so hot next the pulley on each side that he could not bear his hand on it!

He, however, made the test, which showed 4¼ horse power, and then left the frame standing still and reported the fact of the heated shaft to the superintendent, at his office. The writer was at that time very busy and was called away in another direction, and neglected to follow the case up himself, but he is convinced that the other lengths of shaft, at either end, held it steady in its boxes, so that they showed no signs of heating, while the continual strain on the centre of the shaft,

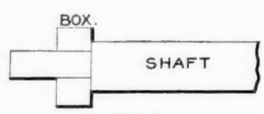


FIG.1

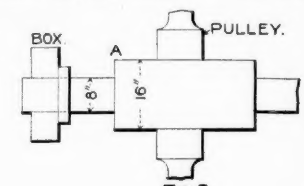


FIG.3

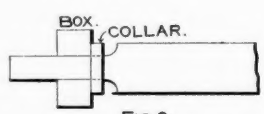


FIG.2

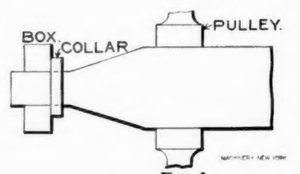


FIG. 4

was producing "buckling" and slow disintegration. He has never met with a similar case, but it warned him to look out for lateral as well as torsional strength in the future! The torsional strength, at the speed of 250 R. P. M., was ample for 40 h. p. about which it was driving, but the lateral strain of 1-10 that amount affected it in that "bay."

It may have been previously sprung, before putting up, and the writer has always regretted that he did not look farther into the matter. In the case of first lengths which are known as: "Jack Shafts," it is best to be on the safe side, and the following points may be noted: First, this first length should extend through the bearings, far enough to receive the couplings to the next lengths, outside of the boxes, and the reduction should be made in the couplings, if the next length is smaller, by boring the halves of the couplings to fit each shaft. Second, a shaft should never be turned down to fit a bearing, leaving a square shoulder, as is often done, and as is shown in Fig. 1.

This is where railway car axles always break, and where the writer has known serious accidents, in lines of stationary shafting.

A thrust collar should always be shrunk on, or fastened by set screws, if there is any thrust to be provided against; and if there is any necessity of reducing the shaft to a less diameter in the box, it should be turned down with a curve, as shown in Fig. 2, and a thrust collar put on. In ordinary cases, the writer would not advise reducing the diameter of a shaft to fit the bearings, but there may be cases in which the shaft has to support a very heavy pulley or gear, in which a large diameter of bearing is objectionable. Such a case, and the accident which followed are shown in Fig. 3, where a 16 inch shaft carrying a

very heavy gear or pulley, was turned down with a square corner, half-way between the pulley and the bearings, shown at A with the result that the shaft broke off square at that point. If it had been tapered down, as shown in Fig. 4, this break would not have happened. This accident happened within two or three years, and was said in the papers to have been on a Corliss engine, but I do not think that my old friend Mr. Cor liss ever committed such a constructive blunder.

In connection with this matter of "first lengths," let me repeat that the transverse strain is more to be guarded against in them than the mere torsional ones, and to again quote Mr Francis, as to the greatest admissible length between bearings for shafts subject only to their own weight—as follows:

For 1 in. diam.	= 12.27 feet.	For 7 in. diam	= 23.48 feet.
" 2 " "	= 15.40 "	" 8 " "	= 24.55 "
" 3 " "	= 17.76 "	" 9 " "	= 25.55 "
" 4 " "	= 19.48 "	" 10 " "	= 26.44 "
" 5 " "	= 20.90 "	" 11 " "	= 27.30 "
" 6 " "	= 22.30 "	" 12 " "	= 28.10 "

These are for wrought iron shafts, and the resistance to flexure of steel varies so little that it may be omitted for the present.

The next point I wish to impress on every one having to do with the practical use of shafting, is the necessity of constant watchfulness to keep it in perfect alignment, and this, with the aid of the adjustable boxes now in common use, can be easily done. But if a "hot-box" is found, the mechanic should not be content with "flooding" it with oil, but should use the tools of the craft—the square, level and compass, to see if it is out of line, and " govern himself accordingly." If line shafting is carefully examined every few weeks and kept true, and in line, a great deal of unnecessary friction will be saved, and few people know how much this sometimes amounts to.

While the writer has found the consumption of power by shafting in the larger cotton mills of New England, where the machines required but a small amount of power each, and were set closely together, to seldom average over 10 per cent. of the total, investigations made by Prof. C. H. Benjamin, and reported to the American Society of Mechanical Engineers, show a consumption of from 50 to 70 per cent., where power was carried a long distance to supply a few machines.

The rapid increase of the system of electric transmission will lead to great changes in the use and distribution of shafting, and it now seems probable that it is to be applied in the future in somewhat the following manner: dispensing with the old main belts and pulleys, and in shops having a large number of small tools in one room, requiring little power each, and in carding and weaving rooms in a cotton mill, driving by long, light lines, each line having its own motor, and wire from the generator.

Where the tools and machines are heavier and farther apart, they may be grouped in lots of 4 or 6, and each group driven from a set of short shafts, such as are usually called "counters," by one motor, and when the tools are very heavy and far apart, each tool will be supplied with its own motor. All systems of shafts, belts or ropes from one building to another will be abandoned, and only such shafting run as is absolutely necessary to drive the tools or machines in operation. As successful examples of the above modes of distribution, I might mention the Baldwin Locomotive Works, of Philadelphia, and the Columbia Cotton Mills, of Columbia, S. C. I have spoken of flooding the shafting with oil, and most of us have disagreeable recollections of hats and coats deluged by the tipping of the old tin "drip pan," which in old times was hung by a wire under the bearing.

Another old abomination was the open top box, in which a block of tallow was laid, and which would not lubricate the shaft till the box got hot enough to melt the tallow!

Some sort of continuous oiler is now generally used, and one of the best is the "Dodge Chain Oiler." I have not mentioned steel shafting yet, and it must be deferred to another letter.

* * *

The Johnston Harvester Co., Batavia, N. Y., provide their foundrymen with a number of good shower baths, with hot and cold water. Would it not benefit mechanics, by influencing other employers to do the same, if it was more generally known to what extent wide-awake concerns are providing such conveniences?

PLANING FLY-WHEEL SEGMENTS.

In these days of heavy steam engines for electric power purposes, massive fly-wheels are in order, and a form that is often met with is that of the segmental wheel, shown in Fig. 1. It consists of a rim, cast in segments, at the center of each of which is an arm which is bolted to one of the flat faces of the center piece, or hub. These segments are held together at the joints by links shrunk into depressions, cored near the end of the segments, the whole making a satisfactory wheel for many purposes, although it is not as safe a construction as some other forms.

There are many ways of machining wheels of this description, and it is the purpose of what follows to tell of one method that must impress the reader as being ingenious, as well as simple and practical. It originated with Mr. A. A. Fuller, when superintendent of the Builders' Iron Foundry shops, Providence, R. I., and has been successfully employed by him in building wheels of this character. The method can be employed only where there is a planer available of unusual size.

The wheel, shown in Fig. 1, has six segments and a brief consideration will show that it is not an easy matter to machine the surfaces for the twelve joints, six of which must radiate from the center of the wheel while the six at the hub must be at angles of 120 degrees with one another. To bring the cost within reasonable limits the segments should be machined together at one time, and after this work is done the wheel should go together with little or no fitting except on the last segment, which can be made of a size and shape that will allow for the inaccuracies of the other joints.

The hub is purely a slotter job, and no special method is used, beyond the old reliable one, which in some shops is special rather than regular, of employing a first-class mechanic who is

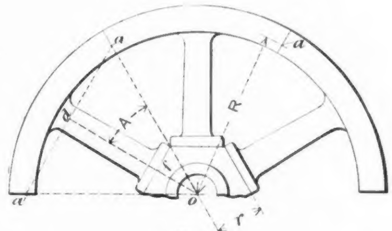


FIG. 1

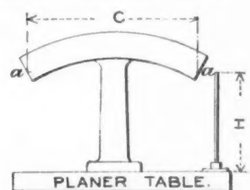


FIG. 2

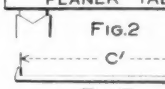


FIG. 3

able to turn out a good piece of work on his own responsibility. The importance of having the hub right at the start is self-evident, for a slight variation in the angles between the faces or in the distances of the faces from the center of the wheel would throw the segments out of place a much greater amount at the rim.

After the ends of the arms are faced on the planer, the arms and segments are stood in a row on the planer table, as shown in Fig. 2, and the faces for the rim joints are planed by the aid of a bevel square for setting over the planer head, a height guage, which is shown standing on the planer table and another gauge represented in Fig. 3.

The purpose is to definitely locate two points, a, a, at the ends of the segments by means of the two gauges mentioned and then, after having set the planer head at the correct angle, to plane off the ends of the segments until the tool passes through these two points. It is determined by calculation that each point should be a certain height, H, above the planer table and that the distance between the two points should be a calculated distance, C. The surface gauge is made of a height equal to H, and the other gauge with a distance, $C' = C$, between its measuring points. Having planed down on each end of the segments, the surface gauge is moved up to the planed surfaces and a line scribed, as at a, a, on each end. The other gauge is then used to see whether the distance between these two points is actually the calculated distance, C, and if it is not another cut is taken, and so on.

The lengths for the two gauges are easily computed. Referring to Fig. 1, it is first assumed that the points a, a, lie on the circumference of a circle having any convenient radius, as R. Connect two of these points by the chord a, a', and complete the right-angled triangle adO. The side $dO = R \cos A$ and the height H (Fig. 2) $= df = dO - r$. The distance, C'. (Fig. 2) $=$ a a' (Fig. 1) $= 2R \sin A$.

PHOTOGRAPHS FROM THE BATH IRON WORKS.

A. L. Graffam.

The views accompanying these notes were collected by the writer during a recent visit at the Bath Iron Works, Bath, Me. This is one of the firms that has taken an active part in the reconstruction of the United States Navy, and a few words about the plant and the work which has been turned out will doubtless prove of interest in connection with the photographs.

This plant started as the Goss Marine Iron Works in 1884, and was devoted to wooden ship-building. Gen. T. W. Hyde purchased it in 1888, and its transformation into a modern shipyard followed. In February, 1894, about $100,000 worth of the property was destroyed by fire, but the damage was soon repaired by well equipped modern structures. At the present time the iron frame of a 319 x 100 feet extension to the machine shop is being erected; and with the advent of warm weather the present crew of 750 men will need to be increased to 1,200 to take care of the work now on hand. These 750 men do not include the 175 employed at the Hyde Windlass Works, which is practically a branch of the same company.

The warship productions of the Bath Iron Works for the American navy include the gunboats Machias, Castine, Vicksburg and Newport, and the armored ram Katahdin. The torpedo boats Dahlgren and Craven are nearing completion, and work has been commenced on the three torpedo boats, Barney, Bagley and Biddel. The schoolship, Chesapeake, is well under way, also. This last is to be a sailing vessel, pure and simple—the first ship built for the American navy without any means of steam propulsion since the Civil War. Its dimensions are given as 225 feet in length, 175 feet on water line, 37 feet beam and 16½ feet draught; with three masts square-rigged throughout.

FIG. 1. ON BOARD THE CHESAPEAKE.

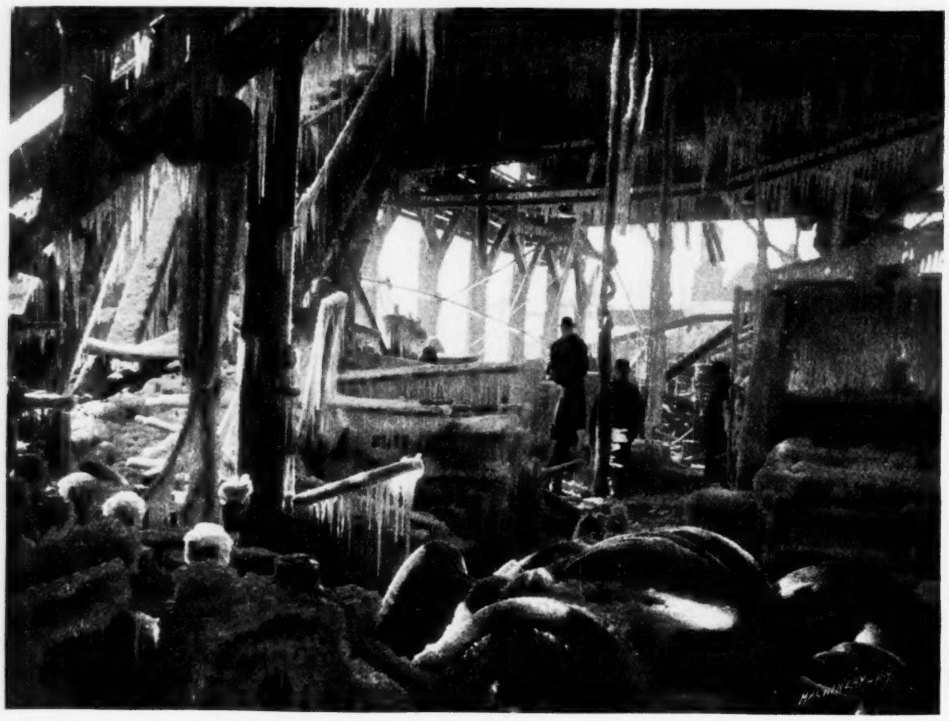


FIG. 2. AFTER THE FIRE.

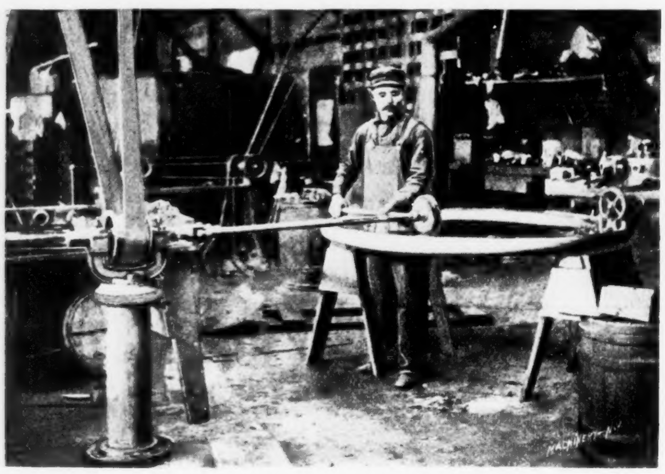


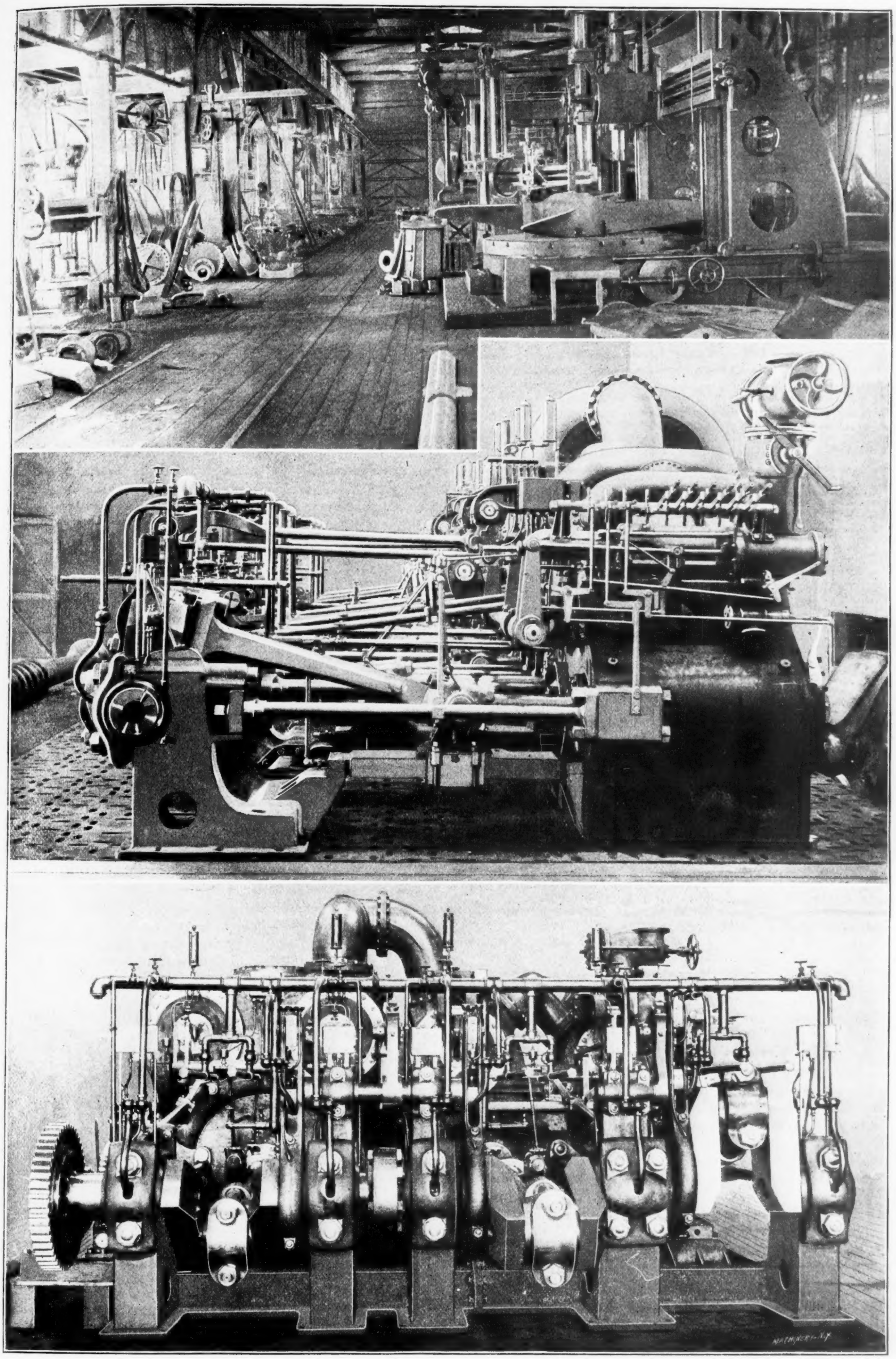
FIG. 3. A RIG FOR POLISHING.

The Katahdin is the well-known ram of our navy. It has a maximum speed of 16.1 knots, the motive power consisting of two double end boilers, 13 feet in diameter and 22½ feet long, and two single end boilers 11′ 3″ long, designs of the Bath Iron Works engineer, Mr. Charles E. Hyde; and two sets of horizontal triple expansion engines, built according to specifications, with cylinders 25″, 36″ and 56″, 36″ stroke, and 4,800 H. P. at 150 revolutions per minute.

Owing to the nature of the work done by the Bath Iron Works, comparatively few mechanics would be benefited by a description of many of the shop methods, but Fig. 3 illustrates a home-made polishing device and is shown because it is so much more easily operated than the squirmy, flexible shaft, although its range is more limited, and it is not so well adapted to a large variety of work. It consists of a short shaft, mounted in bearings on a pedestal, and connected by a universal joint with a long shaft, into which fits a sliding shaft. On the outer end of the latter is a polishing wheel that is applied to the work by a handle fitted to the sliding shaft, close to the wheel.

* * *

It is sometimes the simplest problems that cause the most trouble, and that are also of the greatest value when solved. A foreman of our acquaintance once had a comparatively simple problem on his hands, which, when solved, was very simple indeed, but which, nevertheless, caused him considerable annoyance. It was to make and case-harden large nuts of from three to five inches in diameter, that were occasionally required for the machines that were built by his company. The difficulty was that the hardening process distorted the nuts to such an extent that it was impossible to screw them on to the bolt or rod to which they belonged. The interior of the nuts was well protected by metal cover plates fastened over the ends by through bolts, but the threads would twist out of shape, in spite of them. In attempting to run a tap through the nuts after they had been in the furnace, he found, after ruining two or three taps, that it was an expensive way to true up the thread, and finally hit upon the plan of simply rough boring the nuts before case-hardening, and then finishing the bore and cutting the threads after the outside of the nuts had been case-hardened. This method was very successful, and there has since been no more trouble with case-hardened nuts.



THE MAIN SHOP OF THE BATH IRON WORKS AND THE ENGINES OF THE RAM KATAHDIN.

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MACHINERY

A practical journal for Machinists and Engineers, and for all who are interested in Machinery.

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MAY, 1899.

CIRCULATION STATEMENT.

The regular edition of MACHINERY for May is 16,250 copies. AMERICAN MACHINERY is the title of the foreign edition, printed on thin paper and comprising all the reading and advertising matter in the domestic edition. No subscriber is entered on our mailing list until his subscription is paid for, and all subscriptions are stopped at expiration. No papers are sent free except to advertisers and circulation agents.

The number of copies unsold on April 20th was:

January, 1899,	15	*March, 1899,*	47
February, "	10	*April,* "	89

The circulation of the three leading papers in the Machinery trade, so far as it is possible to obtain the figures, is as follows:

The IRON AGE, about	7,500
The AMERICAN MACHINIST, about	12,000
MACHINERY,	16,250

CONTRIBUTIONS.

To write upon any method or process of manufacture with sufficient accuracy and clearness for the average reader to gain an intelligent idea of the subject, is not a very difficult undertaking if the writer has a full understanding of the matter to be described. To attempt, however, a description of something unfamiliar or only partially understood is work likely to end in unsatisfactory results. We are all familiar with the harrowing efforts of the average daily press reporter, when attempting to "write up" things mechanical, but it is not at all extraordinary that one should flounder when the subject is totally unfamiliar to him as is usually the case with the news reporter who attempts such work.

Grace of diction and fine wording, while desirable, are not necessary for the explanation of the points of a machine or the details of a mechanical process, but a new idea plainly expressed in language perhaps uncouth and ungrammatical, is far preferable to a mass of fine sounding phrases that convey a hazy meaning to the reader. Many shopmen, from their familiarity with manufacturing methods, are far better qualified to write upon the subjects in which they have become expert, than some technical graduates who may be possessed of much general knowledge and the ability to write fluently but who are extremely indefinite upon the details of some subjects.

We believe that a journal of the character of Machinery, to be of continued interest and value to the mechanical public, must have a variety and spice that can only come from different contributors and various sources and to keep in this desirable condition we solicit the contributions of any and all who may have ideas to express of general interest or methods that have resulted in economical production. There are a number of threadbare subjects, however, that it is best to avoid as the opportunities for adding anything new are extremely limited, so that an article on such matters is usually uninteresting and undesirable. Short articles and letters of a column to a page in length on live subjects and bright enterprises are always acceptable, as are usually photographs of new machinery, shop interiors, new tools, etc., when accompanied with clear descriptions.

Very often contributed articles are rejected from no fault of the subject or writing, but simply from an overplus of the same material on hand, the rejected matter being practically a repetition of matter already possessed. Contributors, under such circumstances must not consider that any personal reason has influenced the decision as it is always a matter of regret to be obliged to reject any contributed matter. Contributions accepted and published are paid for in proportion to their worth and not by space rates, as it is not believed that a printer's rule is a reliable guage of the relative values of ideas.

Contributors should follow the practice of writing upon one side of the sheet only and all pages should be numbered in order. After writing an article it is well to read it carefully and to correct all mistakes and if many corrections are necessary much annoyance is often prevented by rewriting it in full. Spare no pains to make the subject plain and always send sketches drawn on a separate sheet if needed to illustrate the meaning in a practical manner.

* * *

SPEEDS AND FEEDS.

It is with pleasure that we are able to add in this number another to the notable articles that have appeared in our columns from time to time upon machine design. The question of the speeds and feeds for machine tools, which is the subject treated in the article mentioned, has not had the attention that it deserves, either by designers in the drawing room or by writers. We believe that we are not exaggerating in saying that it is the exception rather than the rule to find machine tools of any kind, with a gradual change in speeds and feeds, arranged as they should be, in geometrical progression. It is quite common to find a perceptable jump in the speed when changing from back gears to the plain cone drive, and it is not unusual to run across lathes of old design with awkward jumps from one step of the cone to another.

The article upon speeds and feeds is complete in this number and as far as we know is the first adequate treatment of the subject that has appeared. Books upon machine design contain nothing whatever upon the subject and very little has appeared in the technical press. Mr. Stutz explains clearly and fully how the formulas which he uses are derived, and then proceeds to apply them to actual examples which are worked out in full. The examples which he selects are as complicated as any that ever come up in practice, and are more complex than will ordinarily be met with, so that, having once followed the calculations which he gives, there should be no trouble in working out any example that may arise. The problem would be very difficult of solution without logarithms, if indeed it could be solved at all, but by their use it becomes quite simple.

It is often asked why speeds and feeds should increase in geometrical progression. The definition of geometrical progression —a series increasing by a certain multiplier at each step—almost answers the question, for the multiplier serves the purpose of making each step a certain definite per cent. greater than the preceding one, which is the result that should be attained. For example, if it were decided that the cutting speed could vary one way or another 25 per cent., then the steps of the geometrical progression could increase 50 per cent. each time and still bring the speeds within the required limit. A piece two inches in diameter, we will say, would run in a lathe at exactly the right number of revolutions with the speed at a certain step in the progression and a piece three inches in diameter, which is 50 per cent. larger, would run at the correct number of revolutions with the speed one step higher. A piece 2½ inches in diameter,

which is half way between the two other sizes, would then not vary more than 25 per cent, from the correct number of revolutions.

Jumping, now, to a piece 20 inches in diameter, if one speed were correct for it, the next speed would have to be suited to a piece 50 per cent. larger, or one 30 inches in diameter and a piece 25 inches in diameter would run within 25 per cent of the correct speed.

Comparing these two cases, it will be seen that while the two diameters vary by only one inch in the first instance, they vary by 10 inches in the second, and yet the per cent. increase in diameter and the change in speed in the two cases is exactly the same, or 50 per cent. If the diameter increases a certain per cent., the speed must decrease the same per cent. of the previous speed and this result can be brought about only by geometrical progression.

* * *

COMBINED RADIAL DRILL AND BORING MILL.

In the March number "A. L. G." expressed the opinion that a combined radial drill and boring mill would be a useful machine for many shops which have both heavy boring and drilling to do, but not enough of either to warrant the purchase of both a radial drill and a boring mill. Since the publication of this letter the

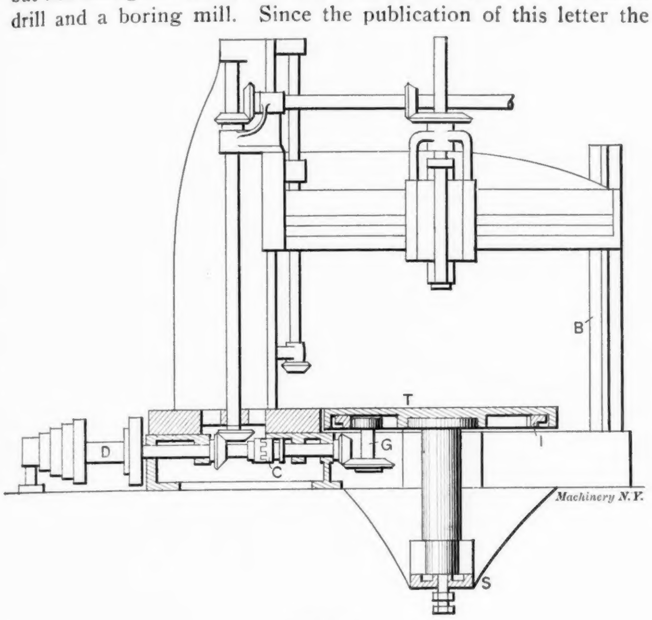


FIG. 1.

Cincinnati Radial Drill Co., Cincinnati, O., have written us that Mr. Anton Mill, of their company, patented a drill and boring mill several years ago that is almost identical with the one illustrated in the March number and that they are prepared to furnish such a machine if desired.

The accompanying sketches are taken from the copy of the patent covering the machine, but with most of the details omitted, the idea being to simply show the general arrangement of the attach-

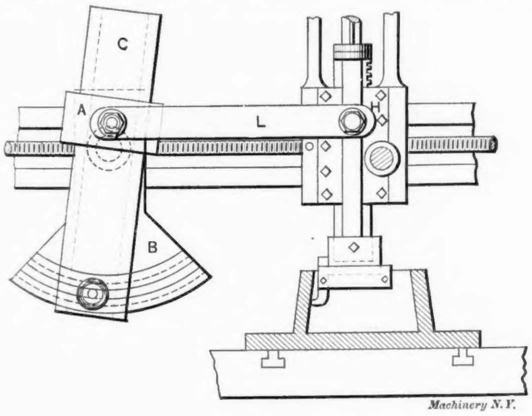


FIG. 2.

ment for boring without attempting to show the features of the drill. In Fig. 1 is a section of the base of the machine which clearly illustrates the driving mechanism for the table. There is an internal gear I under the table, which meshes with a pinion on the upper end of the vertical spindle G. This in turn is driven through the bevel gears shown, by the main spindle D, on which are the cones and the back gears, giving the necessary changes in speeds. The clutch C serves to disconnect the table when not in use for boring. The step-bearing for supporting the table is at S and the support or brace B holds the radial arm rigidly in position. The drill spindle is disconnected for boring by a clutch, not shown, on the horizontal shaft over the radial arm. Any boring mill, to be of general utility, must be designed to turn and bore taper as well as at right angles to the table, and the method of accomplishing this in this machine is shown in Fig. 2. The head, H, does not swivel and the plan is adopted of sliding the head along horizontally on the rail the necessary amount to produce the desired taper, as the tool is fed downward. To accomplish this, a sector, B, is bolted to the rail on which swivels a straight guide-plate, C. The block A, is connected to the head H, by the link L, and slides upon and is guided by piece C. Now by giving C the right inclination, the head will be moved horizontally the necessary amount, the block A being fed downward by power in conjunction with the tool.

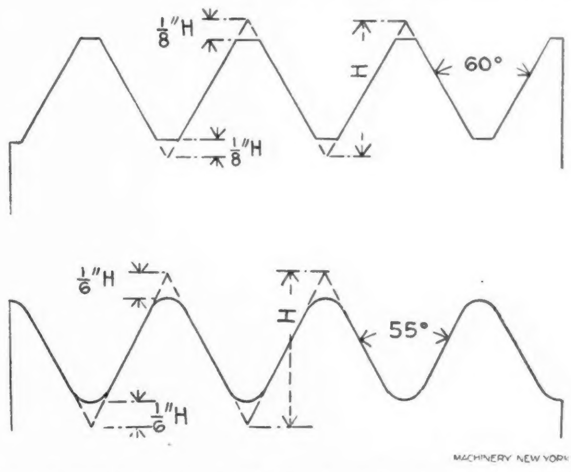
Another feature of a machine of this description is that for a great variety of drilling the radial arm can be kept clamped securely to its brace, and the drill and work brought into the right relative position by rotating the table and moving the head along the arm.

* * *

WHITWORTH VS. SELLERS THREAD.

The following quotation from Low and Bevis' "Manual of Machine Drawing and Design" presents the relative merits of screw threads shaped according to the Whitworth and Sellers system, respectively, as seen through English eyes. The comparison, however, seems to be fair. Without underrating the good points of the Sellers thread, we believe that the Whitworth thread has its good points also, and that they are not as fully appreciated in this country as they might be.

"Comparing the 'Whitworth' and 'Sellers' screw threads, the former is stronger than the latter because of the rounding at the root. The point of the Whitworth thread is also less liable to injury than the Sellers. The form of the Sellers thread is, however, one which is more easily produced with accuracy, in the first place, because it is easier to get with certainty an angle of 60 degrees than an angle of 55 degrees, and in the second place because it is easier to make the point and root perfectly parallel to the axis than to ensure a truly circular point and root. The



Sellers thread has also a slight advantage in that the normal pressure, and therefore the friction, at every point of acting surface is the same; while in the Whitworth thread the normal pressure, and therefore the friction, is greater at the rounded parts. The surface of the Sellers thread will therefore wear more uniformly than the surface of the Whitworth thread. The total friction, and also the bursting action on the nut, are slightly greater in the Sellers thread than in the Whitworth, because of the greater angle of the V. From a comparison of tables of dimensions of Whitworth and Sellers screws, it will be seen that for a given diameter of screw the diameter at the bottom of the thread is greater in the case of the Whitworth than in the Sellers. A bolt with a Sellers thread is therefore weaker than the same size of bolt with a Whitworth thread. The strength of the Sellers screw is still further reduced on account of the sudden change of the cross section of the bolt at the bottom of the thread."

A NEW SHOP SYSTEM.—3.

DEALING WITH THE ORDERS FROM THE SHOP, THE COST OF LABOR AND MATERIALS, THE DISTRIBUTION OF PLANT CHARGES, THE COST KEEPING, ETC., AS CREATED TO MEET THE REQUIREMENTS OF A PLANT DEVOTED TO THE MANUFACTURE AND SALE OF MACHINE TOOLS.

GEO D. CHAPMAN.

A portion of the writer's system has been previously published in MACHINERY, under dates of March and April, 1898, and it will be necessary at times, in this article, to refer to these numbers.

Every successful manufacturing plant to-day has its system of orders, plant charges, etc. This must be so, for competition is now so sharp and prices are so low, that without a thorough knowledge of one's business,—which knowledge can only be obtained by system—the profit and loss account would appear upon the wrong side of the balance sheet.

This article will show one system for getting at facts and arranging them in an accessible from. The orders and other forms for this system will first be described and then the method of using them, believing that the subject can only be made clear by showing the actual order, etc., used.

A Bureau of Information, which consists of a List, is posted in each department. This gives the class insignia of each Tool, as 13L, meaning 14 in. Gem Lathe, etc., and also the abbrevitations for stock, as C. I., meaning cast iron, etc. The significance of the List, together with its handling is described in MACHINERY, March, 1898. The terms referring to different lists, etc., are capitalized.

Casting, Tool Steel and Miscellaneous Lists.

Lists are made for each Part of each size of Tool, i. e., in the case of a lathe there are separate Lists for the Headstock, the Tailstock, the Compound Carriage, and for every other Part.

Each Part has a Casting list, which gives in columns the Name of each casting piece in that Part, the pattern number, (Pat. No.), the Stock, and the number of pieces (No. Pcs.) for one Tool; also has a column headed On Hand, one headed Date and one headed Start.

Each Part also has a Steel list of a similar form, sample lines of which are here shown. Then there are Miscellaneous Lists, which list in a similar manner, for each Tool, all such pieces as are neither of casting or of steel; as leather, brass, etc.

The system of pattern and piece numbering is explained in MACHINERY, March, 1898.

Refering to the Casting list.

The Vs in the On Hand column are put on with a red pencil by the Order Clerk as he marks up the patterns for the foundry, thus readily showing at any time just what the foundry has in progress. Referring to any List, the Vs in the margin opposite the pieces are put on with a red pencil by the Stock Clerk when the total number of pieces specified on the List, in the Start column, have been received by him and have been delivered into the Stock Received room, ready for the shop. This gives a ready means of ascertaining just what pieces have been received.

"STOCK REC'D."
10-18-98.

G. S. R. is stamped upon the List by the Stock Clerk when he has marked all the pieces on the List in the margin with red Vs.

The figures to the right of the names of the pieces are the weights of each piece and are put on, with black pencil, by the Stock Clerk. These weights are put on only when Wts. Wanted is written upon the List, as in this case.

The weights put down are, of course, the rough weights, and these are wanted only when the weights have not been previously taken. These weights furnish the stock items used in figuring the costs, later to be described.

These blue print Lists are the only orders for pieces which are used in or issued to the shop. In fact they are the piece orders. By ordering the pieces in this manner it makes a condensed, correct and simple system.

FIG. 1.

Wts. Wanted. Stock rec'd
5-3-'97. FITCHBURG MACHINE WORKS. 10-18-'98. **L-332**
CARRIAGE. G. S. R.
13 L-4 GEM. L-$\frac{317}{6}$ CASTINGS.

NAME.	Pat. No.	Stock.	No. Pcs.	On Hard	Date.	Start.	NAME.	Pat. No.	Stock.	No. Pcs.	On Hand.	Date.	Start.
√ Carriage Gib..............4.	13L 68	C. I.	1	2 √	'98 9-14	158	....	....	....	....	....	....	....
√ " 69 68	13L 69	"	1	√	"	60	....	....	....	....	....	....	....

FIG. 2.

Wts. Wanted. Stock rec'd
5-12-'97. FITCHBURG MACHINE WORKS. 10-11-,98. **L-334**
CARRIAGE. G. S. R.
13 L-4 GEM. L-$\frac{317}{6}$ STEEL,

NAME.	Diam.	Length.	Piece No.	Stock.	No. Pcs.	On Hand.	Date.	Start.	NAME.	Diam.	Length.	Piece No.	Stock.	No. Pcs.	On Hand.	Date.	Start.
√ Cross Screw ....7.	$\frac{13}{16}''$	$17\frac{3}{4}''$	13L 0074	B. S.	1	......	'98 9-14	160	Poppet Ring............3.	......	......	13L 005	B. S,	1	......	'98 9-14	1 60
√ Comp. " 3	$\frac{3}{4}''$	$7\frac{13}{16}''$	13L 0075	"	1	......	"	160	" Wedge...........2.	......	......	13L 0088	"	1	..	"	1 60

CASTING AND STEEL LISTS.

Size 10 x $6\frac{3}{4}$ inches. Material light colored blue-print. (These lists are all filled in as returned to Engineering Department.)

Piece No. Tags.

One piece in each lot in progress has a Piece No. tag attached to it, which serves as a tally for the stock clerk in receiving the stock and assists in keeping same correct after it has been put into the shop.

Suitable boxes are provided, sizes 12" x 8" x 6" high, 16" x 12" x 8" high and 24" x 16 x 10" high, some of which are divided in the middle, the partition running the short way, for receiving and handling the stock. These boxes, together with special trucks for handling same, have saved many hours of rehandling and have, to a large extent, prevented the loss of pieces in progress.

O

Fitchburg Mach. W'ks.

PIECE OR JOB NUMBER 13L 69

LOT OF 60

NO. OF PIECES REC'D.

60

Date 10-9-98.

FIG. 3. PIECE NO. TAG.

Size $1\frac{5}{8}$ in. x $3\frac{1}{4}$ in. Color buff. (All filled in as attached to pieces in Stock Received Room.)

The Record.

A Record list is made for each size of machine or Class. This Record gives in columns, under each Part, all the drawing numbers and also List numbers of casting, steel and miscellaneous lists, which refer to said Part.

Lower down on the Record is given a list of the Parts of the machine and also columns for keeping account of the Parts on hand, started, etc.

The Records are filed upon the Record file board in the order of the Classes of machines and are provided with index guide sheets, which are tabbed. The Record list with the method of keeping same always up to date is fully described in the March, 1898, issue of MACHINERY.

Tool Card.

Each Tool, as completed, has a consecutive Tool No. stamped upon it and under this No. an arrow; the arrow is put on simply to distinguish this No. from others upon the Tool.

When each Tool is completed it has its individual Tool card as shown below.

To explain, 2014 is the Tool No., 14 x 6 L Gem is the name of the Tool, in this case 14 in. swing x 6 ft. bed Lathe, Gem style, 1-11-'99 is the date the Tool was completed. $\frac{\text{L-317}}{6}$ is the Record according to which the Tool was built, and which gives all the details in regard to the construction of the Tool. The sub. 6, is significant of the lot i. e., this is the sixth lot of this size of machines built.

2014		14 x 6 L GEM.
1-11-'99	L-317 6	Compound carriage. Auto. stop apron.
....	....	....
1-2-'99 1-12-'99	....	Jones Mfg. Co., Jonesville, Mass.

FIG. 5. TOOL CARD.
Size 2 in. x 5 in. Color blue. (All filled in as a sold tool.)

The Inspector's Report of the same No. i. e., 2014 gives the details of inspection. 1-2-'99 is the date the Tool was sold. 1-12-'99 is the date the Tool was shipped.

3-22-'97 FITCHBURG MACHINE WORKS. **L-317** 6

TOOL NUMBERS.
2005-2006-2007-2008-2009
2010-2011-2012-2014

13 L GEM
STARTED 9-14-'98

RECORD
COMPLETED ....

DRAWINGS.

1	1	2	4				8		11	12	14	14	15	18	19	20		Ass.
1664	....	1674	1689	....	....	....	1681	....	1688	1685	1697	Metric	1695	1666	1693	1692	....	1729
1665	....	1675	1690	....	....	....	1682	....	....	1686	1718	....	....	....	....	....	....	....
1696	....	1676	1691	....	....	....	1683	....	....	1688	....	....	....	....	....	....	....	....
1667	....	1677	1694	....	....	....	1684	....	....	1727	....	....	....	....	....	....	....	....
1668	....	....	....	....	....	....	1728	....	....	....	....	....	....	....	....	....	....	....
1669	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1670	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1671	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1672	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	L-496	....
1678	L-319	L-325	L-332	....	....	....	L-327	....	....	L-331	L-323	....	L-333	....	L-323	L-323	L-322	....
	L-318	L-324	L-334	....	....	....	L 328	....	....	L-330	L-335	L-390	L-336	L-326	L-335	L-335	L-320	....

CHANGES.

2005-2006-2007-2009-2012 Metric screws, etc.
2008-2010-2011-2014 Regular.

Class.	Part.	On hand.	Date.	Start.	Date.	Comp.	Used.	On hand.	Date.	Start.	Date.	Comp.	Used.	On hand.
1	Headstock........................	L-117 5	'98 9-14	60	'99 1-3	√	....	....	....	....	....	....	....	....
2	Tailstock........................	1	"	59	'98 12-16	√	....	....	....	....	....	....	....	....
4	Carriage Compound................	....	"	60	'99 1-2	√	....	....	....	....	....	....	....	....
.	....	....	....	....	....	....		....	....	....	....	....	....	....
8	Apron............................	....	'98 9-21	60	'98 12-23	√	....	....	....	....	....	....	....	....
..	....	....	....	....	....	....		....	....	....	....	....	....	....
11	Screw (spline)...................	4-6[1]	10-11-'98 "	20-6[1] 5-8[1]	'98 12-30	√ √	....	....	....	....	....	....	....	....
11	" " Metric.......................	6-6[1]	" 1-3-'99	15-6[1] 10-8[1]	12-30-'98	√	....	....	....	....	....	....	....	....
12	Hangers, screw...................	....	'98 9-15	60	'98 12-23	√	....	....	....	....	....	....	....	....
14	Screw gears—studs................	....	"	40	'98 12-30	√	....	....	....	....	....	....	....	....
14	Screw gears—metric...............	12	'99 1-2	30	....	....	....	....	....	....	....	....	....	....
15	Steady rest (4″ opening).........	....	'98 9-14	60	'98 12-16	√	....	....	....	....	....	....	....	....
18	Countershaft.....................	....	"	60	'98 12-14	√	....	....	....	....	....	....	....	....
19	Legs.............................	....	'98 10-10	120	'99 1-2	√	....	....	....	....	....	....	....	....
..	....	....	'98 9-21	6 ft. "	1-5-99 "	√ √	2005 2006	....	'98 9-21	6 ft. 6 "	....	√ √	....	....
..	....	....	"	" "	" 1-9-'99	√ √	2007 2008	....	'98 12-23	8 " 8 "	....	....	....	....
..	....	....	"	" "	" "	√ √	2009 2010	....	"	8 " 8 "	....	....	....	....
20	Bed..............................	....	"	" "	1-10-'99 "	√ √	2011 2012	....	"	6 " 6 "	....	....	....	....
..	....	....	"	" "	1-11-'99	√ √	2014	....	"	6 " 6 "	....	....	....	....
..	....	....	"	" "	....	√ √		....	"	6 " 6 "	....	....	....	....
..	....	....	"	" "	....	√ √		....	"	....	....	....	....	....
..	....	....	"	" "	....	√ √		....	"	....	....	....	....	....

FIG. 4. RECORD.
Size 10 in. x 13½ in. (All filled in to date.

13L	Total.	Tool Nos.	Wts.	Sales.
1899. Jan........	4 F 5	1987-1990-1991-1992F 1993 2000-2005F 2006F 2007F	10800	1920
Feb........	5 F 8	2008-2009F 2010-2011-2012F 2014	14600	2830
March......	....	1111 FFF	....	....
April......	....	....	....	....
May........	....	....	....	....
June.......	....	....	....	....
Total......	....	....	....	....
Br't. for....	115 F 95	....	252,620	42,580
Total....	....	....	....	....

FIG. 6. TOOL SOLD CARD.
Size 3 in. x 5 in. Color blue.

These Tool cards when the Tool is sold are filed in the Sold Tool till, numerically, behind number guide cards.

Tool Sold Card.

The Tool Sold cards are made out in advance for the year, two cards for each size of Tool, or Class, one containing Jan. to June inc., and the other July to Dec. inc.

TOOLS SOLD.

1899. SUMMARY.

13L	33L	SS	18P	B & DM	RD
14L	36L	21WL	24P	1D	CD
16L	42L	27WL	26P	2D	1S
18L	48L	8HL	30P	3D	2S
21L	54L	10HL	36P	4D	S Total
24L	60L	13HL	48P	5D	Spec.
27L	72L	16HL	60P	D Total	....
30L	L Total	HL Total	P Total	....	Total

FIG. 7. SUMMARY TOOL CARD.
Size 3 in. x 5 in. Color white.

The column of Sales is filled in each month on all the Tool Sold cards direct from the Order Book; taking the actual prices there given for the Tools sold that month. The weights of the Tools sold are figured at the same time and the amounts entered in the Wts. column on the proper cards.

These cards are filed in Class order, the cards for each year being kept together.

A Summary Tool Sold card is made out each year to give a quick index of the class of Tools sold. This card is filed in front of the Tool Sold cards for that year.

Trade Sold Card.

A Trade Sold card is made out for each party to whom a tool is sold and contains all the tools ever sold to said party. If further details are desired in regard to prices, etc., of any of the tools sold this party, the Order Book can be consulted, and under the date given upon the Trade Sold card in the Date column this information can be found. If details in regard to the construction are wanted consult the Tool card of the same No. as given in the Tool No. column upon the Trade Sold card and trace it back through the Record and the drawings.

The Trade Sold cards are filed in the Trade Sold till alphabetically according to the name, behind alphabetical guide cards.

Name. Buyer.
Jones Mfg. Co. J. H. JONES, Supt.
Town, Jonesville. State, Mass.

Sold Tools.

Date.	Tool.	No.	Date.	Tool.	No.	Date.	Tool.	No.
'87			'93					
3-7	48 x 24L	174	1-30	18 x 8L	872	....	....	....
"	36 x 12P	178	"	"	873	....	....	....
'89			'99	GEM				
5-12	36 x 14L	317	1-2	14 x 6L	2011	....	....	....
"	18 x 8L	320	"	"	2014	....	....	....
"	18 x 4P	260	....	....	....	....	....	....

FIG. 8. TRADE SOLD CARD,
Size 3 in. x 5 in. Color salmon.

The Trade Sold cards are cross indexed upon Trade cards under the head of towns, each Trade card having lines for eight parties, and the parties, as far as possible, are arranged alphabetically upon the card.

These Trade cards also contain the names of the prospective customers, so that to distinguish between the past and the prospective customers a V is put in the column opposite the party's name whenever a Trade Sold card is made out for said party.

MASS.		JONESVILLE.
....	√	Adams Mill Co.
....	.. ....	Doane Machine Works.
....	√	Jones Mfg. Co.
....	....	....
....	....	....
....	.. ....	....
....	....	....

FIG 9 TRADE CARD.
Size 3 in. x 5 in. Color blue.

The Trade cards are filed in the Trade till behind the proper state guide card and alphabetically arranged according to the name of the town. Additional cards are made out for each town as required.

Inspector's Report.

When each Tool is completed the Inspector tests it and makes his report upon the blank given below, which he then sends to the Engineering Dept.

FITCHBURG MACHINE WORKS.

INSPECTOR'S REPORT.

Name of Machine.
14″ x 6′ Gem Lathe.

Style Carriage, Compound.
" Apron, Aut. stop.
" Feed, Chapman.
" Countershaft, Barnes friction.
Scraped by Wrenn.
....
....

REMARKS.

Regular,
....
....
Date Completed, 1-11-'99.
Tool No., 2014.

FIG. 10. INSPECTOR'S REPORT (FRONT).

INSPECTION.

If Lathe.
Back Gears unloaded, A; loaded, A.
Feed " " A; " B.
Long Center at $\frac{0}{1000}$ in. at 12 in. $\frac{1/2}{1000}$ in.
Alignment (Head and tail centers), A.
Facing (Small face-plate), A.
Turning length of bed, low tail end, $\frac{1/4}{1000}$ in.
Turning " " " $\frac{1/2}{1000}$ in.
....
....
....
Inspected by G. T. Prince.
Approved by W. F. Ray.

FIG. 11. INSPECTOR'S REPORT (BACK).
Size 5 in. x 8 in. Color brown. (All filled in as reported.)

New Machinery Order and Shop Order.

These Orders are made in triplicate, the original is for the Shop, and is given to the General Foreman, and the duplicates are for the Office and the Engineering Dept.

The form of the order books being novel, will perhaps bear description. These orders are made in pads, the cardboard back of which slips into a leather cover, there being of course, one cover for the New Machinery Orders, and one for the Shop Orders. The three blank orders are printed with the middle one on the front of the sheet, while the other two are on the back. The whole sheet is 15 in. long (three times the width of the orders), and 8⅝ in. high. The sheets are then perforated once lengthwise ⅝ in. from the top and twice crosswise, dividing the sheet into thirds, so that if the orders are now torn apart each of the three would be 8 in. high by 5 in. wide.

These sheets are bound together into pads, the binding being done lengthwise at the top, for which the ⅝ in. part of the sheet is left.

In the middle, fastened to the binding are two carbon sheets, placed carbon side down, 5 in. wide and long enough to reach to the bottom of the sheet.

To write the triplicate orders it is only necessary to allow one of the carbon sheets to rest upon the middle order, which is printed face up, tear the right hand order along the lengthwise perforations and fold it over the middle order, bringing this second order now face up; then the second carbon sheet and the left hand order are handled in a like manner, which locates the three orders ready for the writing; after being written they can be torn out and apart.

The carbon paper is always attached, so it is more quickly handled than if inserted, and in fact the whole operation can be done in much less time than it has taken to describe it. The same idea would give five or six copies successfully, with thin paper and a hard pencil.

FITCHBURG MACHINE WORKS.

NEW MACHINERY ORDER.

To the Foreman: One Machine wanted, as follows:

14″ x 6′ Gem Lathe (13L), compound carriage and complete.

....

....

....

Total 111 "Shop Orders" issued. Total 111 Returned.

For Jones Mfg. Co.
Location, Jonesville, Mass.
When completed stamp below and immediately return to office.
1-11-'99. J. L. G.

Issued 1-2-99 by W. F. R.
Shipment promised, 1-14-'99.
Shipment made, 1-12-'99.
Tool No 2014.
File on 13L. Pc. No. —. D lot of 60.

FIG. 12. NEW MACHINERY ORDER.

Size 5 in. x 8 in. Color brown. (All filled in as returned to Engineering Department.) 1-11-'99.

J L G is the stamp, which the general foreman puts upon the "New Machinery Order" when the Tool is completed, then this Order proceeds upon its course.

The "File On" at the bottom of the Order refers to the Cost system.

FITCHBURG MACHINE WORKS.

SHOP ORDER.

To the Foreman: Make as follows:

For 13L Gem Lathe. 60 compound carriages.

....

....

....

Charge all time on "Daily Time Slips" to Piece Numbers.
When completed stamp below and immediately put in "Return Box."
1-2-'99. J. L. G.

Issued 9-14-'98 by W. F. R.
To be completed Jan. 1, '99.
Stock ordered, 9-14-'98 by W. F. R.
Castings (except C. S.) received 10-18-'98. Cast steel, 11-16-'98.
Steel received 10-11-'98.

When this "Shop Order" is returned, check on "New Machinery Order."
Completed 1-2-'99, and received by G. S. R.
L-332 334
File on L. Pc. No. —. D lot of 60.

FIG. 13. SHOP ORDER.

Size 5 in. x 8 in. Color, white. (All filled in as returned to Engineering Department.) 1-2-'99.

J L G is the stamp put upon the Order by the general foreman when the parts there specified are completed, he then delivers the Shop Order and the parts to the Stock Receiving Clerk who makes his entries and puts the Order into the Return Box. This box is examined each morning, at a fixed hour, so that the Order is brought early to the Engineering Department where it proceeds upon its course.

The File On at the bottom of the Order refers to the Cost system, which will later be explained.

Triplicate Order.

For this purpose the Hano triplicate order books are used, of the ordinary form.

9-14-1898.
13L
Castings.
Compound carriages.
60 set as per L-332. Received 10-18-'98. G. S. R. S. O., W. F. R.

FIG. 14. TRIPLICATE ORDER.

Size 4 in. x 6 in. (All filled in as returned to Engineering Department with list L-322.)

Received 10-18-'98. G. S. R.

G S R was stamped upon the above order by the Stock Clerk to show all of the stock specified on L-332 was received.

* * *

Ball bearings are now applied to almost all kinds of machinery, with a consequent saving of power required to do the same amount of work. But why cannot we have ball bearings for the trucks, used so much in freight depots and shops; also, on the humble wheelbarrow? Almost anything that makes work easier means a reduction in the cost of production.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

TO KEEP THE SHAFTING CLEAN.

W. McFarland, Port Richmond, S. I., writes:

Not long ago, while on board a steamer, I saw a device on a high-speed engine which to my mind, though simple, fulfilled its purpose fairly well and for that reason it is entitled to due consideration. Its application is possible wherever high-speed engines are in use and where the employment of help beyond that which is absolutely necessary, is impracticable.

When a shaft is running at a high rate of speed and where put up in lengths of ten to fifteen feet, it is usually found that the lubricant fed to the journals finds its way from between the shaft and box and forms in rings around the shaft on each side of the bearing. This oil should, of course, be cleaned off or it will become hard and result in a dirty shaft or fall on forbidden ground at a time, most likely, when least desired.

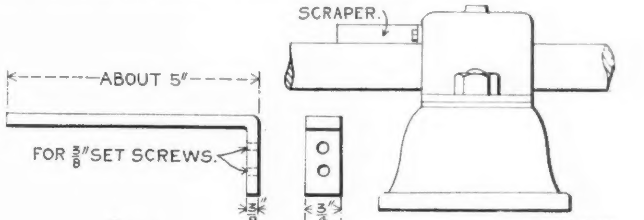


FIG. 1 FIG. 2

On the engine referred to, this trouble was obviated by attaching to the side of the pedestal top a small piece of a shape like that shown in Fig. 1. This is made of wrought-iron or steel about 1/4″ thick, 3/4″ wide and about 5″ long from the point of attachment to the bearing, to the end. It is fastened to the side of the pedestal by two 3/8″ screw-bolts and when in position should be a trifle out of parallel with the axis of the shaft with the point leading as the engine runs ahead. The edge next the shaft should be sharpened so as to catch the grease more readily. It will of course, be understood that what lubricant is used on the bearing can be caught and lead to drip-pans below and again used, but if wiped off with waste it will probably be of no further use.

Fig. 2 shows the device as applied to a shaft, and it will be seen that the same device can be used to good advantage in many other places.

A HANDY DEVICE.

Mr. Arthur Munch, of Brainard, Minn., sends the following simple method of holding work to the live center when using the steady rest. It has the features of always being in balance, which is a manifest advantage at high speed.

The part shown at G Fig. 3 is made of belt leather cut out to the shape shown and of the size required to suit the lathe and work in hand.

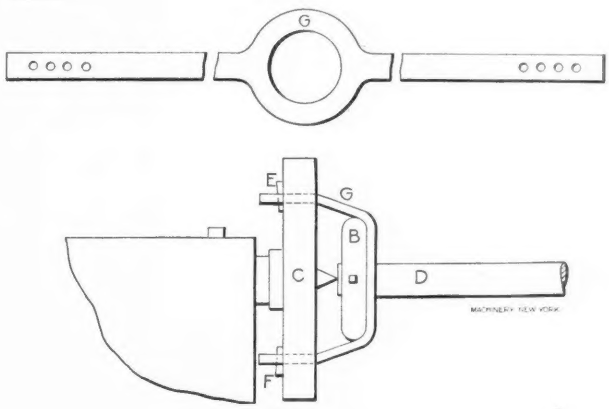


FIG. 3.

The face plate, C, Fig. 3, is backed off the spindle about 5/8 inch, and the leather piece G slipped over the work, and then the pins E and F put in place. The dog B is then shoved to the right as far as it will go and tightened in place. The face plate being now screwed back to the shoulder, tightens the strap and brings the work squarely onto the center.

The holes in the face plate should be cut so that the width of

the strap ends D will just fill, and save the bother of the pins dropping from place when the work is removed. Split keys can be used instead of the pins, and thus overcome this difficulty if desired.

USEFUL ATTACHMENTS TO THE LATHE.

Mr. F. H. Jackson, of Angelica, says:

Fig. 4, A, shows a very handy tail-stock attachment for a lathe. A centre is turned up to fit tail-spindle as shown at B, to which a face-plate is fitted. There is a shoulder C, made on the back of the plate on which is fitted a short piece of tubing ,D, by screws, as shown at E. The inside of the tubing makes a good fit over the end of the tail-spindle, which relieves the tail-centre from the strain when pieces are fastened on the plate for drilling or milling. Of course this tubular piece can be made with the face plate, but the above style of fitting will be easier for some amateurs.

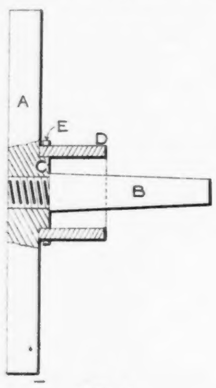


FIG. 4.

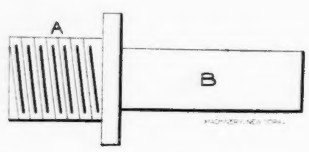


FIG. 5.

Fig. 5 is an attachment to fit into the boring-tool holder that every lathesman has, the part B going into holder and an ordinary face plate screwing onto A. With the holder fastened on a compound rest and an angle-plate on the face-plate a very efficient milling machine can be made by running cutter in chuck in head-spindle.

Ingenious mechanics can utilize these attachments in a variety of ways.

FOR CENTERING STUBB'S STEEL.

A handy and time-saving device is described by Mr. J. R. Shott, Toronto Junction, Can., in the following words:

Fig. 6 is a sketch of a jig for centering Stubb's steel which is intended to be turned in the lathe. It does away entirely with the practice of marking a piece with a centre-punch and spinning it between the centres of the lathe to see if you have it true, and if it don't happen to be true enough to clean up (for it is almost impossible to get it perfectly true that way) why keep on trying until it is, and after you have taken all that trouble likely as not when you start the centre-drill in it will "run" and undo all your

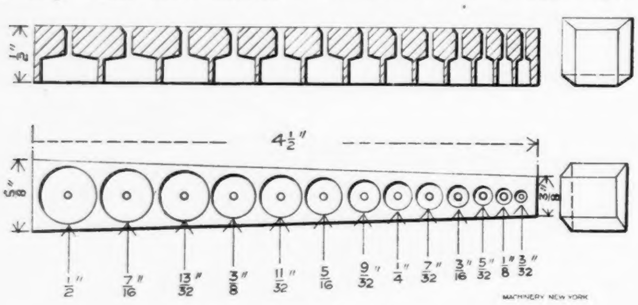


FIG. 6.

labor. I have the holes graded the same as the sketch and the center-drill holes graded to suit the different sizes of steel which the jig will take. I use the jig either in the speed-lathe or the drill-press by inserting the work in the jig and running the center-drill down through the hole in the jig provided for it. The stock will come out centered perfectly true.

AN AGRICULTURAL JOB.

A machinist who signs "Win," in writing of his experience, says:

A machinist never knows what kind of job he is going to strike so I will give the readers of MACHINERY the benefit of my experience with broken gear-teeth some time ago.

Last summer, while on a visit to a farm in central Maryland, the gear connected with the mechanism for tying the bundles on a self-binder broke in the middle of harvest. The agent for that make of binder did not have a gear in stock and had to send to Ohio for another. The farmer began to worry about his wheat standing so long and said to me: "If you are a machinist, let me see you fix my binder." I took the gear (Fig. 7) to the village smith and had him forge three pieces like A. (There was not a machine shop within twenty miles.) I then went to work, chipped and filed the broken teeth down as shown by the dotted

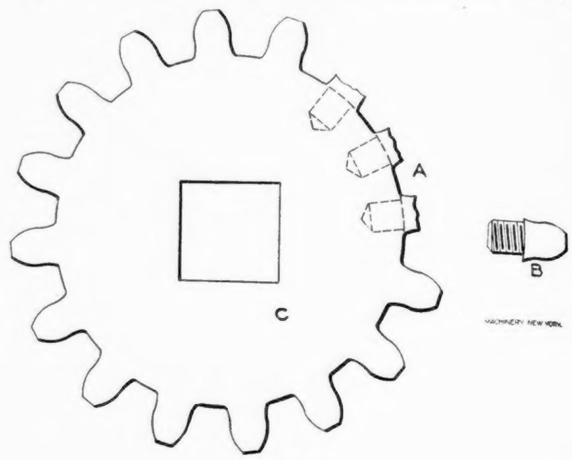


FIG. 7.

lines at B, drilled and tapped holes in the center of the spaces just worked down, ran a die over the shanks of the forged teeth and screwed them in the tapped holes. I had to file the shoulder down a little on the forged teeth so that they would come in the right position when screwed down. The gear ran all right, and the farmer says he is going to cut another crop with it.

I have fixed broken feed notches on planers and shapers the same way, only I drilled holes and drove in pins.

FOOT-STOCK TOOL HOLDER.

Our friend Milo sends this useful kink, among some others, which he picked up at Springfield, O.

Another Springfield device with the bayonet hitch was found on a lathe at Mast, Foos & Co.'s, but I cannot trust my memory enough to assure the readers that Fig. 8 is an exact representation of it. A special foot stock, with the spindle operated by hand through a rack and pinion, was provided. The nose of the spindle, C, was threaded, and B, with the bayonet hitch, was

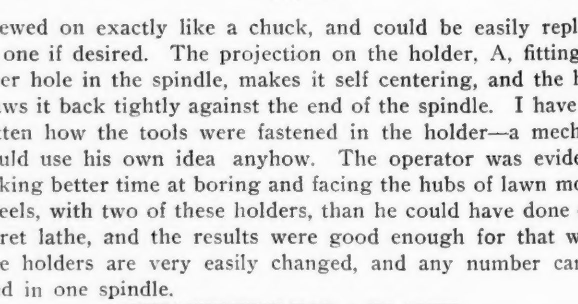


FIG. 8.

screwed on exactly like a chuck, and could be easily replaced by one if desired. The projection on the holder, A, fitting the taper hole in the spindle, makes it self centering, and the hitch draws it back tightly against the end of the spindle. I have forgotten how the tools were fastened in the holder—a mechanic would use his own idea anyhow. The operator was evidently making better time at boring and facing the hubs of lawn mower wheels, with two of these holders, than he could have done on a turret lathe, and the results were good enough for that work. The holders are very easily changed, and any number can be used in one spindle.

ATTACHMENT FOR A PLANER.

Fig. 9, is a sketch of a planer attachment sent in by G., and is used for planing out engine guides, instead of boring. While it seems that boring would be preferable to planing in such work, the device is certainly worthy of consideration, as it has other fields in which it could be profitably employed.

The apron is removed and the part P, which is made to take its place, is fastened by the same pin, L. The star, E, turns the worm J, which meshes in the worm wheel, H. The wheel H is mounted on the end of the shaft I, which runs through P and

carries on its outer end the part B, which forms a support for the small apron, C. The regular tool post, M, and washer, D, are used. The apron is held down by the spring F.

D is the tappet for striking the points of the star E. Different circles can be obtained by lengthening or shortening the reach of the tool.

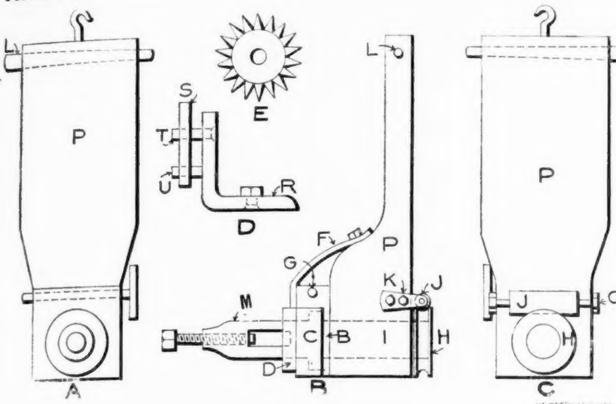


FIG. 9.

G. has neglected to show how he gets his feed, as by the method shown the tappet will strike the star on both the forward and backward strokes, but this difficulty can be overcome by using a ratchet in E.

Fig. 10 is a tool holder made of iron or steel for a turret lathe. The end, B, is round and fits into the turret, or may be flat and held in the tool-post of a machine lathe. The tool, C, fits into a slot and is held by the set-screws, D. This rig is convenient in working brass, making nuts, etc. The mandrel, E, fits into the hole, F, in the body, A, the end, E, is run into the hole in the work, which is thereby steadied while the tool is cutting.

Fig. 11 is a boring-bar to be held in the tool-post slot in a lathe. A great advantage of a bar of this kind is that it permits the tool to cut ahead of the bar. A number of equi-distant holes are drilled through the bar, for the purpose of adjusting it to different depths. The bolts, C, have counter-sunk heads. The tool is easily held in position by the set-screw, G.

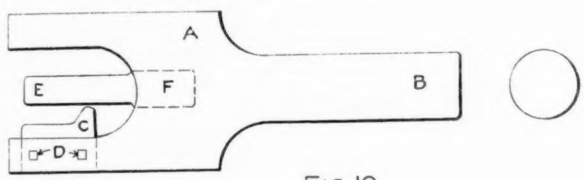


FIG.10

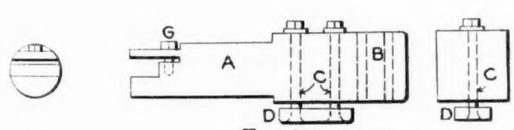


FIG.11

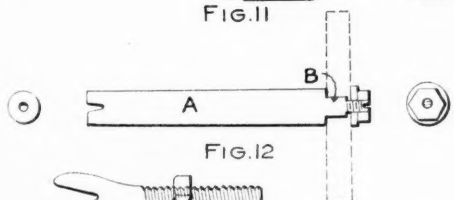


FIG.12

FIG.13

Fig. 12 is a mandrel for turning washers. The washer is driven on at B and a nut is screwed up holding it against the shoulder of A. The washer is faced, one side at a time; when the tool is close to the nut, unscrew it and finish facing.

Fig. 13 is a handy device or jack for a planer or boring-mill. One end is shaped like a fish-tail and the other end is threaded. A piece of pipe can be slipped over the threaded end, against the nut, and it can be used as a brace for work, or as a jack, etc.

EXTENSION FOR TWIST DRILLS.

It often occurs that a very long drill is needed to reach a hole on account of the nature of the surrounding parts. The form of extension sent by Mr. M. D. Watrons, of Ansonia, Conn., can be used to advantage in such cases.

In Fig. 14 the piece A is a rod of machinery steel, cut to any convenient length to suit the job, with a hole, B, drilled in the end the size of the drill to be used. Two cuts are then made in the rod at the bottom of the hole as shown with a hack saw down to about ¼ the diameter of the hole, B. After cutting out the lands between the cuts a piece of steel is laid in the cut and caulked in so that it is solid. This forms a feather for holding the drill, F, which is ground off on the side as shown at G to

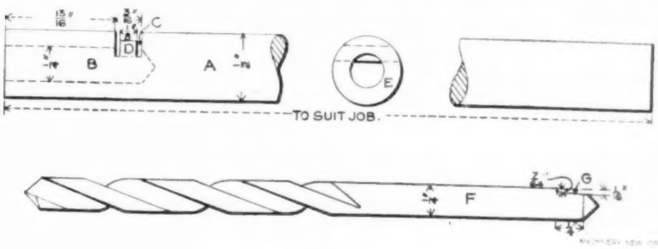


FIG. 14.

pass by the feather. The amount the feather projects into the hole, B, is indicated by the section E. This method gives a positive drive and it does not spoil the drill for other work as is the case when a piece is welded on to the end to get the required length.

TO PUNCTURE A COMPOSITE PLATE QUICKLY.

Mr. Harry Gunther, of San Antonio, Tex., evidently has a great deal of respect for the penetration of the modern rifle bullets. It may be that they have a way of doing greater execution in Texas than farther north. He says:

"A banker sent for me several years ago to come to his bank, and when I arrived he took me into the vault and said that he wished me to put a peg in the side of the wall. The vault was lined with five steel plates about ¼" thick, three of which were soft steel and two of hardened steel, arranged as shown in Fig. 15. He asked me how long it would take me to put a hole in the plate, and I told him that I could do it in less than a second after I commenced. He said then that the safe company had guaran-

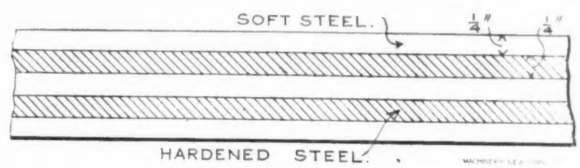


FIG 15.

teed it to be "drill proof," but I told him that I could put the hole in it if he wanted to pay me for the trouble. He then backed out, but wanted to know how I would do it. I replied that was my business and that all he would have to do would be to pay the bill and it would be done.

The way that I would have put the hole in the lining would be to have borrowed a rifle from a hardware store across the street, and the "kink" would have been worth seeing.

* * *

THE WATCH A COMPASS.

Very few people are aware of the fact that in a watch they are always provided with a compass, with which, when the sun is shining, the cardinal points can be determined. All one has to do is to point the hour hand to the sun, and south is exactly half way between the hour and the figure 12 on the watch. This may seem strange to the average reader, but is easily explained. While the sun is passing over 180 degrees (east to west) the hour hand of the watch passes over 360 degrees (from 6 o'clock to 6 o'clock). Therefore, the angular movement of the sun in one hour corresponds to the angular movement of the hour hand in half an hour; hence, if we point the hour hand toward the sun the line from the point midway between the hour hand and 12 o'clock to the pivot of the hands will point to the south.—Dixon's Teachers' Note Book.

* * *

From an article in the London "Engineering," on the production of tubes by extrusion, the fact is learned that copper and its alloys, when heated and in a plastic condition, can be separated and again reunited by simple pressure, forming a true weld. It is necessary that the surfaces be kept from the air, however, as the rapid oxidizing of the bright surfaces prevents the welding process.

LETTERS UPON PRACTICAL SUBJECTS.

SHAPER DESIGNS.

Editor MACHINERY:

Having had occasion lately to examine a number of different shapers, I was struck with, what seemed to me, to be a notable weakness in design. If the designer were to design a punching press, he would use altogether a different line of reasoning. In the first place, all shapers, tool posts and tools are very small in proportion to other machine tools. A thirty-inch shaper should take as large a cut as a thirty-inch lathe, but it will only permit the use of a tool about half as large as a lathe of this size.

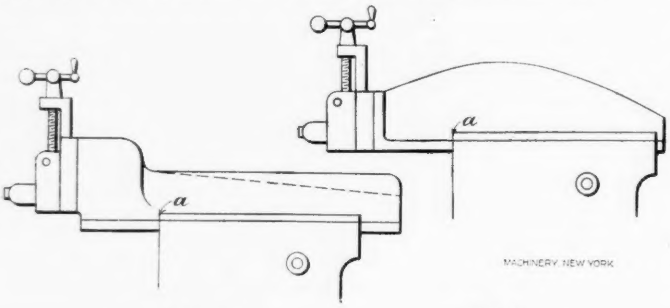


FIG. 1. FIG. 2.

Another misproportion, according to my way of thinking, is the shape of the ram. In some makes the top is parallel with the bottom, as in Fig. 1, while in others it is inclined toward the rear, as shown by the dotted lines. It is plain that the strain is greatest at the point a, and supposing the inclined ram to be extended indefinitely, it would have to be supported in mid air. It is no wonder that shapers plane fan-tailed. They get weaker about as the square of the distance extended. My suggestion would be to design them on the principle of the punching press, as shown in Fig. 2. I believe it is possible to construct a shaper that will be nearly or quite as rigid when the ram is extended as when it is returned. In Fig. 2 it will be noted that the ram is thickest where the pressure is greatest and by this construction the strength is not much, if any, diminished with the extension of the ram. HUGH HILL.

* * *

HOW WE "TOOK" THE STOCK-ROOM.

Editor MACHINERY:

It is no enviable task to take an inventory. This is especially true where the business can not be shut down or interfered with for the purpose, and in this case we had at our disposal for the work Saturday afternoons and Sundays only. A year ago, although the stock was only about one-half the quantity, variety and importance of the present, it was not considered advisable to undertake to complete an inventory of it in a single Saturday afternoon and Sunday; so we went at it piece-meal, with a week's interval between pieces, during which time extra precaution and labor were required to keep accounts straight. This year I decided that the stock must be taken between one Saturday noon and the following Monday morning, and the method in which I accomplished it proved to be both simple and satisfactory.' We carry in stock about fifteen hundred various parts, each of which has a distinguishing name or size. Owing to the fact that the stock-room was undergoing a re-arrangement most of the stock was not properly labeled, and although this department regularly employed three hands who were familiar with the names and sizes of all the parts, it would have been folly to expect three men in the time allowed to count and name fifteen hundred different articles, the quantity of each varying from one to fifteen thousand—the average being in the neighborhood of two hundred each. I proceeded in the following manner: Ten men and boys were engaged to count and each was assigned to a certain division of the stock room with instructions to count the articles in each compartment and write the result upon a slip of paper leaving the slip with the parts counted. I allowed no questions to be asked except of myself and no talking or sociability between the counters, a thing to be insisted upon if an accurate count is desired. I instructed two of the men regularly employed in the stockroom to collect the slips from the compartments and write on each the name and size of the part contained therein, at the same time chalking the compartment to show that the pieces had been counted. The bookkeeper was stationed at a convenient work-bench, upon which was laid a clean planed board having one edge indexed A. B. C., etc. (the names of all parts carried in stock, having previously been arranged on inventory sheets in alphabetical order) and as the slips bearing the counts were delivered from the stock-room they were assorted in alphabetical order along this board.

The counting and classification of slips was finished after fifteen hours' work. The count was all entered upon the inventory sheets three hours later, one man taking up the slips in their order, calling the name, size and number of pieces, the clerk entering the number of pieces opposite the proper name on inventory sheets. This allowed an average of about seven and one-fifth seconds for the reading of each slip and the entry of the number on the sheet.

Considering the amount of stock handled, I believe this is above the average for rapidity and accuracy.

In connection with the foregoing, it might be well to suggest to those to whom stock-taking may be a new experience, the fact that scales will count large quantities of parts which are finished all over such as pins, studs, washers, collars, screws, etc., with greater accuracy and rapidity than human fingers. For instance, put enough of the stock onto the scales to balance at an even pound mark. Now, if seventeen pieces weigh five pounds, you will not be able to balance the scales with any number of these pieces at any even pound mark below the fifth.

In this case seventeen pieces weigh five pounds, and we have, say fifty-one pounds, proceed simply thus: $51 \div 5 \times 17 = 173$ pieces.

Another way of counting with scales where the leverage of the scales is of a convenient ratio is this:

Suppose the weight used to balance one hundred pounds upon the platform actually weighs one pound, (leverage of scales 100 to 1,) the stock may then be placed upon the platform and for each piece of the same stock put upon the disc in place of the weights to balance the scales there will be 100 upon the platform. Suppose for illustration a half keg of rivets is dumped upon the platform and it is found that seventeen of the same rivets placed upon the weight receptacle just balances. We evidently then have 1717 rivets, (don't forget the number you use in the place of the weights.) Suppose, however, that 17 will not balance and 18 will more than balance the amount on the platform, then leave 17 upon the weight receptacle and slide the weight on the beam until it balances. Suppose the poise to be at six ounces, we then have $1717 + 6\text{-}16 \times 100 = 1754 +$ pieces.

CLAY BEAU.

* * *

THE FALLACY OF LIQUID AIR.

Editor MACHINERY:

Nothing is more facinating to the layman than the discussion of a transformation of heat-energy into work; and nothing is more difficult to explain in popular language and more difficult to understand than this transformation. Things are said and facts and theories are advanced that appear very plausible and easy of comprehension to any one who is *not* acquainted with even the fundamental laws governing the science of energy. Very often these statements are launched for the purpose of creating a speculative boom and a market for a doubtful commodity. Sometimes, indeed, the claims are made in good faith, and the fallacy is not perceived by those who propose these claims. Such, undoubtedly, is the case with the writer of the article on "Liquid Air," in the March number of "McClure's Magazine."

Mr. Tripler is made to say: "I have actually made about ten gallons of liquid air in my liquefier by the use of about three gallons in my engine. There is, therefore, a surplusage of seven gallons that has cost me nothing and which I can use elsewhere as power." Then follows a vision and a rhapsody by the author of the articles, Ray Stannard Baker.

Let us examine this statement in detail, and do a little simple figuring! Assume in the first place that we are to transform one pound of air. At first this pound of air is drawn into the compressor at a temperature of the room, say 70° F., and at atmospheric pressure, 15 pounds per square inch. It is then compressed to about 2,500 pounds per square inch, or 167 atmos-

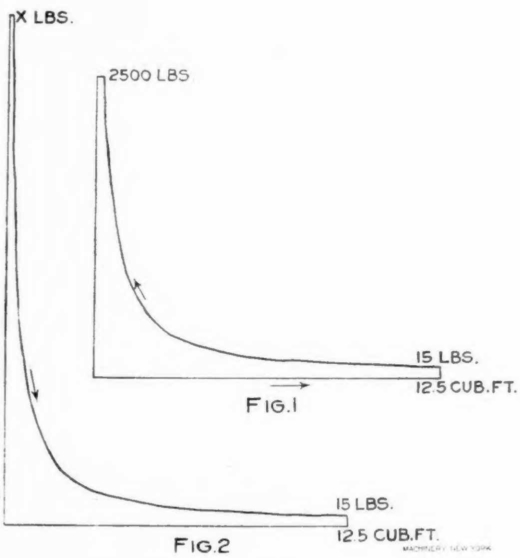
pheres, and is then pushed into the cooling pipes, where it falls in temperature to about 50°.

The work done upon the air is represented by the indicator diagram, Fig. 1. If we assume a cooling water-jacket surrounding the compressor, then the area of the diagram representing the work done on the air will be the smallest possible, and therefore this assumption errs on the side of generosity.

The volume of the pound of air, at atmospheric pressure (15 pounds) and at the given temperature, 70°, is known to be about 12.5 cubic feet. The area of the diagram is easily found to be equivalent to

$$(15 \times 144 \times 12.5 \times 2.3 \times \log \tfrac{2500}{15}) \text{ foot-pounds.}$$
$$= 69,100 \log 167 \text{ foot-pounds.}$$

According to the description of the liquefier, this compressed air is divided into two parts; one of these parts passes through a set of pipes and is ultimately liquefied, while the other portion expands around these pipes and cools the air within them to the temperature of liquefaction, absorbing also the so-called latent heat, in a manner similar to the cooling produced in an ordinary surface-condenser. To judge from the descriptions of the process, this expansion of the cooling air is *not* used in helping the compressing engine, as in the ordinary refrigerating machinery, but simply produces a current of cold air rushing past the first pipe with great velocity and chilling it down to 312° below zero. No data are given as to what fraction of the air compressed is liquefied; we are told, however, that the *entire* pound of air that has been compressed is *not liquefied*!



Let us now go to the other end of the process. A pound of liquid air is confined in a closed vessel and is exposed to the heat radiated from the objects in the room, and also takes up the heat carried to it by the air surrounding the vessel. At once it begins to boil and soon the entire pound of liquid has been evaporated into vapor or gas at the temperature of the room, 70°, and at a considerable pressure. Allow this air to enter the cylinder of our compressing engine, and let it complete the stroke by expanding until the pressure has fallen to 15 pounds per square inch. If we assume the most favorable condition, then, provided the expansion takes place very, very slowly, the heat continually entering from the surrounding air will prevent a fall in temperature.

Fig. 2 will now represent the work developed by the pound of liquid air supplied under the most favorable conditions. Now, it is evident that this area must be greater than the area of Fig. 1, in order that only a fraction of the pound of liquid air need be used to perform the work necessary to liquefy one pound. This increase of area can be obtained only by raising the pressure in the "air-boiler." (If we are to reason from analogy with steam, this pressure will depend on the temperature in the "boiler," and can not possibly pass a definite limit. No data are available to determine this pressure in the case of air. On the contrary, it must be granted that no pressure high enough has as yet been found sufficient to liquefy air at ordinary temperature.)

Let us, therefore, be generous and assume that almost any pressure may be produced in the air-boiler. The problem then becomes simply this: What initial pressure is required to make the area of Fig. 2 a given number of times the area of Fig. 1?

Let x = this pressure.

a = the number of pounds that are to be liquefied by one pound of liquid air; i. e., the ratio of Fig. 2 to Fig. 1.

$$\text{Fig. } 1 = 69,100 \log \frac{2500}{15}.$$

$$\text{Fig. } 2 = 69,100 \log \frac{x}{15} = a \text{ times Fig. } 1 = a\ 69,100 \log \frac{2500}{15},$$

$$\text{therefore } \log \frac{x}{15} = a \log \frac{2500}{15} = \log \left(\frac{2500}{15}\right)^a \text{ and } \frac{x}{15} = \left(\frac{2500}{15}\right)^a$$

that is, the number of atmospheres pressure required must be 167 raised to a power indicated by the ratio **a**.

If **a** = 1.5 X = 2,158 atmospheres.
a = 2 X = 27,890 "
a = 2.5 X = 360,400 "
a = 3 X = 4,658,000 "

Since it is stated that only 3-10 of the liquid air made was used, then the power developed per pound must be at least 10-3 times as large as that used for compressing, for each pound of air.

Hence $a = 3\ 1/3$, and $x = 167 \times 167 \times 167 \sqrt[3]{167} = 25,650,000$

If we now assume that only *one-half* of the air compressed is liquefied, then a = 20-3, because one pound of liquid must develop enough power to compress 20-3 pounds of air.

Whence X = 658,000,000,000,000 ats = nearly 1,000,000,000,000,000 pounds per square inch, provided there be no friction or other loss of energy!

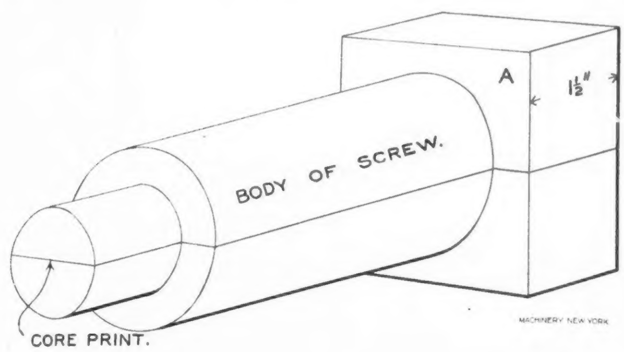
WILLIAM FOX.
College of the City of New York.

* * *

MAKING A CASTING FOR A WORM.

Editor MACHINERY:

In your number for April, in the column of "How and Why," question and answer 87, F. A. N. asks how a pattern can be made for casting a worm. In your answer you say the only point to look out for is that the angle of the sides of the thread be great enough so that the pattern will draw out of the mould, etc., all of which is to the point and proper.



Thinking a little trick in moulding a double-threaded worm might interest some one, I send you the following account:

The writer was called upon to cast a double-threaded worm about 1⅛" pitch. There seemed to be plenty of draft or clearance to the threads, but when it was attempted to draw out the half pattern, it would come about 1-16" and no further without disturbing the mould. After cogitating the "how and why" it was determined to dig out the sand at the end of the pattern, as the pattern gave evidence of wanting to crawl endwise. When this sand was removed, the half pattern was easily twisted upon edge, as it may be termed, and came out of the sand all right, without disturbing a particle of the mould. After that a wooden end was made in two parts, to set against the end desired. Said blocks were something larger in every way than the extreme diameter of the worm, and 1½" thick, as I believe the pattern had to travel 1¼" to get the right elevation. Cores were made to fill the space left by each part of the block with provision for supporting the core print of the worm, and there you were. I have seen a great many of these worms cast with this arrangement and many of them without evidence of a seam, so neatly did the pattern draw when on edge.

I think it would be difficult to draw a double-threaded worm

in any other way and get a casting true to the pattern, but single-threaded screws with square threads are made without much trouble.

The enclosed sketch is not intended to show a screw or worm, but is simply to indicate how the wooden end, A, was placed against the pattern to make space for the end travel of the pattern when it was drawn from the sand as before mentioned. This method worked finely in every way. L. C. JEWETT.

North Attleboro, Mass.

* * *

CAP-SCREWS, BOLTS AND STUDS.

Editor MACHINERY:

The subject of wire gauges that has received attention in your columns is not the only one of a practical nature that is somewhat "hazy" to the average mechanic. Bolts, cap-screws, and kindred articles are almost as confusing and are as often called by their wrong names as by their right ones. In fact, I am inclined to think that these parts are more frequently indicated incorrectly on drawings than otherwise and one has but to tend stock room for a short time to observe the confusion regarding the sizes, names, standards, etc., of these small but important pieces.

Far be it from my intention, however, to attempt to straighten out the matter for the readers of MACHINERY. I had something of the sort in mind when I began, but it required only a brief comparison of the standards adopted by the different bolt and screw manufacturers to place me in the position where I should be glad to have some one else straighten out the matter for me.

I will content myself, therefore, with saying a word about the names of the various screws and bolts. In Fig. 1 is shown a row of cap-screws. On a number of drawings that I have examined screws like Nos. 1 and 2 are variously called "machine bolts," "tap-bolts," and "cap-bolts," but never cap screws. Nos. 3 to 7 are almost invariably called "machine screws" and the terms designating the shapes of the heads are sometimes clear enough to show what is wanted and sometimes not.

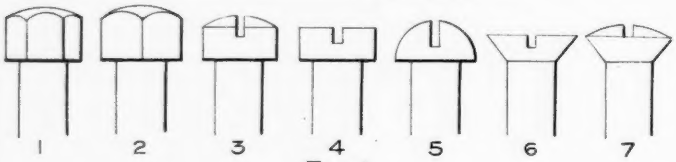


FIG.1

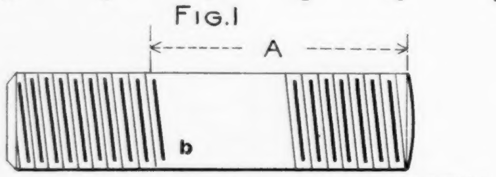


FIG.2

Cap-screws are made in sizes of diameter that are even quarters, eighths or sixteenths of an inch and the number of threads per inch conform to the United States standard. Machine screws are made in sizes agreeing with the machine screw gauge, the number of threads conforming to the machine screw standard. The shape, size or style of head has no significance whatever in determining whether a screw is a cap screw or a machine screw.

On the other hand, the main difference between a cap-screw and a machine-bolt is in the size and shape of the head. Hexigon head cap-screws have heads approximately as long as the diameter of the screw and their short diameters about ¼ inch larger than the diameter of the screw. Square head cap-screws have correspondingly long heads, also, the short diameter being about ⅛ inch larger than the diameter of the screw, for ordinary sizes. Machine-bolts have shorter heads, as a general thing, and of a diameter nearly as large as that of the United States standard bolt. A cap screw is used to bolt one piece, which is not threaded, to another piece which is threaded, while a machine-bolt is more often used as a through bolt, to hold together pieces, neither of which are threaded. A cap-screw, therefore, is usually threaded up further than a machine-bolt.

Any bolt threaded nearly to the head and which is intended to be used in a tapped hole without a nut on the end is properly called a tap-bolt. Some manufacturers make tap-bolts with heads like those of hexigon or square head cap-screws and others adopt other styles.

In point of finish, bolts are supplied any way desired, rough, milled under head and on body, with head faced on top, head polished, etc. Nuts are furnished rough, with the tops trimmed and chamfered or not, as desired; semi-finished (faced on the bottom); or finished and case-hardened.

Referring to Fig. 1, Nos. 3 and 4 are properly called filister head screws, No. 3 with oval and No. 4 with flat head. Sometimes, however, No. 3 only is called a filister head and No. 4 a round head screw. No. 5 is a button head, No. 6 a flat or countersunk head and No. 7 goes by the name of French head. These names apply to machine screws as well as to cap-screws except that with the latter the button-head screw is quite commonly called a round head screw.

In this connection I should like, also, to raise the question as to the best method for making and using studs, as shown in Fig. 2. A stud must be a tight fit in the place into which it screws, as otherwise it will loosen in its place when the nut is unscrewed. It seems necessary, therefore, either to have the stud bottom in the hole or else to have it screw up to the end of the thread, at b in the figure. It has been my experience, at least, that studs are not made accurately enough nor holes tapped so that one will always be a tight fit in the other unless the stud is screwed up against the end of the thread or the bottom of the hole. Of the two, I prefer to have the stud bring up against the end of the thread, because it is not always possible to drill and tap holes all of the same depth, and I have to suggest that the dimension A on the sketch should always be given and that this distance should always be measured in inspecting the product. It would save sending back studs because they are a little too long or a little too short for the place in which they are to be used.

OLIN SNOW.

* * *

ON TIME KEEPING.

Editor MACHINERY:

Having seen from time to time articles in MACHINERY on shop methods and time-keeping systems, I will describe a system that I have established in the manufacturing shop of the Thos. Philips Co., of Providence, R. I.

From the experience gained in several shops I have learned that much time is lost by the men in running to the tool-room for their tools, also that many mistakes are made in the numbers on their time-checks. This system has been worked out to remedy these troubles.

When the orders come into the office, they are placed on the books and numbers made out with descriptions of the work to be done as in the following sample:

25655—SPECIAL B.

One 4 can Back Drying Machine 60" in diam., 48" face, 4½ lb. copper, steel heads, complete with 8-5½" brass water rolls, friction batcher with wrought-iron shaft, outside stand and 17" plate.

There will be no arrangement for stretcher or 5" brass drag rolls, otherwise the machine will be the same as F. O. 25419.

To be done 3 weeks from Dec. 28, 1898.

04825—Copper work.
04826—Tee iron rings.
04827—Turning lips.
04828—Mounting and testing.
04829—Iron work.
04830—Scoops.
04831—Cast iron frame.
04832—Journal bearings.
04833—Gears.
04834—8- 5½" brass water rolls.
04835—Friction batcher .

These descriptions and numbers are then sent into the tool-room to the time-keeper, and he furnishes the numbers to the workmen until the job is finished. The time-keeper and the tool-maker being one in this shop, which employs about thirty-two machinists and sixteen helpers, furnishes each man with a time-card each day, which has the day of the week, the month and the year and also ten brass checks.

TIME CARD.

Name, Jones.
Occupation, ...
Date, 3-17-99.

No. of Job.	Time.	No. of Machine.	Time Machine.
04982 25839	4 6		
	10		

The time-keeper also has a book indexed with the men's names and allows about twelve pages to each man.

The workmen are furnished with a drawing and a slip of paper, by the foreman when they commence a job. The slip gives the time of starting the job and also describes briefly what they are required to do as shown by the following sample:

No. 2.

3.05 P. M.

Jones,....................

Framework for 32-cam dryer

04897 (furnished by the time-keeper.

The foreman also explains the job verbally. The workman then takes his slip to the tool-room, the time-keeper gives him a number to charge his time to, also writes the time of commencing the job. The same number is also filed in the time-keeper's book under the workman's name. While at the tool-room getting the number of his job, he also gets all the tools necessary to finish it, thereby saving many useless trips after tools. For each tool a check is left, after the usual practice, which is hung on a peg over tags describing the tool removed.

When a job is finished, a report is made to the foreman, who signs the slip with the time finished and gives him a new job and slip marked also with the time.

The two slips are then brought with the tools to the tool-room, and the time-keeper enters the time, gives him a number for the second job together with the necessary tools and also enters it on his book.

If the second job is not finished that day, it is carried over onto the next and sometimes for a week until the work is finished.

JAMES F. COYNE.

East Providence, R. I.

* * *

PRACTICAL PROBLEMS.—7.

PROBLEMS 13 AND 14 WITH ANSWERS TO 11 AND 12.

13.—To Find the Velocity of the Periphery of the Disk.

A disc C, Fig. 1, made of cast-iron 1½" thick and 24" in diameter is mounted on the shaft B which has its ends enlarged to 4" in diameter. The ends B, of the shaft rest on two parallel ways A, which are inclined from the level 30°. The distance from D to

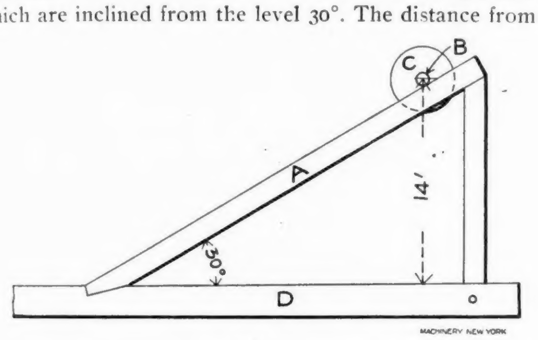


FIG. 1.

the center of the shaft is 14 feet. If the disc be allowed to roll down the incline from the position shown, what will be the velocity of the circumference of the disc when it reaches D? No allowance to be made for friction, the disc being considered as solid and the weight of the shaft being disregarded.

14.—To Analyze a Variable Speed Device.

Two taper drums or cones A and B are mounted as shown and driven in opposite directions by the two belts C and D. Belt C has a velocity of 2,160 feet per minute and belt D, a speed of 1,800 feet per minute. When the belt C is in the position shown the mean diameter of the portion of the cone encircled is 12" and that of the belt D is 10". When the belts are shifted to the extreme left the conditions are exactly reversed.

Each cone carries on the inner end a bevel gear F, F, and meshing in these gears are the two small bevel gears E, E. The latter are mounted on a loose sleeve J, which turns freely on the shaft M. Forming a part of the sleeve J is the gear K, of forty-eight teeth, which drives the two pinions I, I, and the gears H, H, which are each firmly united with I, I. The united gears I, H and I, H turn on pins held in the part G, which, as will be seen, forms a bearing for the cone B, and extends through it to the right, being keyed in the bracket N. The gears I, have sixteen teeth and the gears H forty teeth. The gear L, which is keyed on the shaft M, has twenty-four teeth, and is driven by the gears H, H.

Wanted the number of rotations of M in a minute with the belts in the position shown and running at the speeds given.

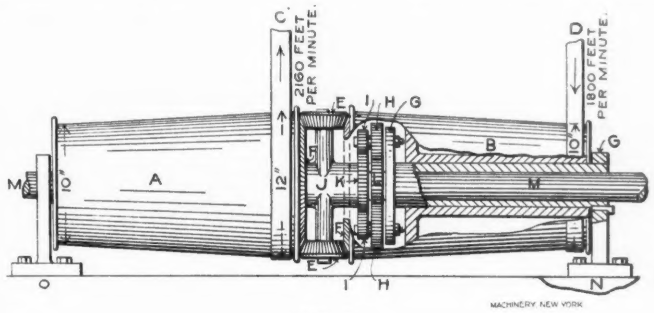


FIG. 2

Also with the belts in the middle points of the cones and with them to the extreme left, no allowance to be made for the slip of the belts.

ANSWERS TO PROBLEMS 11 AND 12.

Mr. C. Albert Wettengel, of Pittsburg, Kan., has solved problems 11 and 12, with the following results:

PROBLEM 11.—We first find the weight and the center of gravity of the combination of bar E and ball B, as shown graphically in Fig. 3. The center of gravity of the bar is at one-half the measured distance from either end or 34.75" from end P. Taking this center as the axis, the distance X to the center of gravity of the ball and bar equals:

$$\frac{18.18 \times 37.25 = \text{moment of the ball}}{80.09 = \text{weight of the bar and ball}} = 8.455''\text{ and}$$

$$Y = 34.75'' + 8.455'' = 43.205''.$$

Weight of ball C is

$$\frac{6 \times 6 \times 6 \times .5236}{1728} \times \frac{480}{1} = 31.416 \text{ lbs.}$$

$$\text{The lever arm} = 16'' \times \cos .30^\circ$$
$$= 16'' \times .866 = 13.856''$$

The moment of C is therefore $= 13.856 \times 31.416 = 435.30$ inch pounds. To be in equilibrium the moment of the ball B, and the bar E must equal and be opposite to the moment of the ball C. Therefore,

$$\frac{435.30 \text{ moment of C}}{80.09 \text{ weight of B and E}} = 5.434''\text{ distance}$$

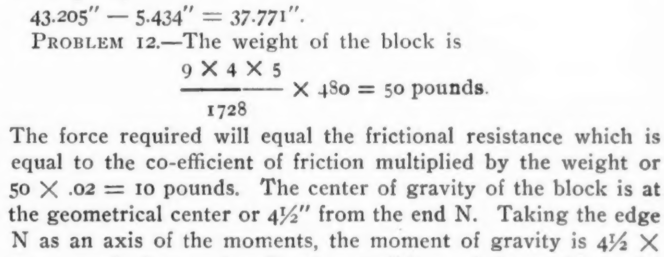


FIG. 3.

that the center of gravity of B and E is to the left of the center of the pulley, or the end of E projects to the right of the center of the pulley.

$43.205'' - 5.434'' = 37.771''$.

PROBLEM 12.—The weight of the block is

$$\frac{9 \times 4 \times 5}{1728} \times 480 = 50 \text{ pounds.}$$

The force required will equal the frictional resistance which is equal to the co-efficient of friction multiplied by the weight or $50 \times .02 = 10$ pounds. The center of gravity of the block is at the geometrical center or 4½" from the end N. Taking the edge N as an axis of the moments, the moment of gravity is $4\frac{1}{2} \times 50 = 225$ inch pounds. By the conditions of the problem, the moment of gravity and of the force are equal and opposite, hence;

$$\frac{225 = \text{moment of gravity}}{10 = \text{force K}} = 22.5''$$

length of lever arm K. The point O, at which the force K acts is 22.5" above the lower surface of the block.

In the solution of Mr. Elmer G. Eberhardt, of Newark, N. J., we have a slightly different method but with the same result.

Problem 12.—As the co-efficient of friction is twenty per cent., and the weight of the block

$$\frac{180}{1728} \times \frac{480}{1} = 50$$

pounds the force required at K to slide the block will be twenty per cent. of 50 pounds or 10 pounds. Now in order that this 10 pounds shall just raise the block, the ring O must be at a certain point above the top of the block which height we will designate as x". As the leverage of O is equivalent to x" + 4", and the force is 10 pounds then the moment of K is 10 (x + 4), which must just balance 50 pounds with a leverage of 4½", since the center of the block swings about the point N.

Hence $50 \times 4\frac{1}{2} = 225$ inch pounds.

Then $10 (x + 4) = 225$ " "

$10 x = 185$ " "

$x = 18.5''$ height of O above the block.

Mr. Charles Stecher in his solution of problem 11 assumes that the weight of the ball B is concentrated at the end of the bar B.

PROBLEM 11.—To find the distance of the end of the bar E from the center of the pulley, when the combination is in equilibrium, first find the center of gravity of the bar E and the ball B independently. Then find the distance of the ball C from the center of the pulley along the bar E, that is, where the cord will intersect the bar. Now with the latter we have a fixed weight, and its projected distance from the center of the pulley can be easily determined. Now if we assume that the weight of the bar and ball is concentrated in one point of the bar, and ball is concentrated in one point, and then find the center of gravity of the two, we can afterwards add to the distance found from the center, the distance that the end of the bar is from this point.

Weight of the bar E = 61.9 pounds.
" " ball B = 18.2 "
" " " C = 31.4 "

The center of gravity of the ball and the bar measured from B = the weight of B ×½ the length of the bar, ÷ the sum of the weights of the ball and the bar — ½ the length of the bar or

$$\left(\frac{18.2 \text{ lbs.} \times 34.\tfrac{3}{4}''}{61.9 + 18.2}\right) - 34.\tfrac{3}{4}'' = 26.855''$$

Distance of the cord from the center = $16'' \times \text{Cos. } 30^\circ = 16 \times .866 = 13.856''$. Since the weight of B and E = 80.1 the distance that their center of gravity is from the center of the pulley =

$$\frac{31.4 \times 13.856}{80.1} = 5.431''$$

$26.855 + 5.431 = 32.286''$ distance of ball B from the center. $69\frac{1}{2}'' - 32.286'' = 37.214''$ = distance that E should be from the center of the pulley.

A number of replies were received to No. 11 that failed in accuracy, also some that pursued a faulty method in solution. Problems involving the finding of the center of gravity of two objects when connected, are readily solved by the formula

$$l = \frac{w\,L}{W + w}$$

in which l = length of the short arm, L, the total length of the connecting link, W, the larger weight and w, the smaller weight. Thus to find the center of gravity of two weights, one weighing 10 pounds, and the other 6 pounds when connected by a bar 5 feet long, the weight of the bar not being considered, we have

$$l = \frac{6 \times 5}{10 + 6} = 1\tfrac{7}{8} \text{ feet}$$

length of the short arm. $5 - 1\frac{7}{8} = 3\frac{1}{8}$ feet, length of the long arm. To prove the result multiply each arm by its respective weights and the results must be equal. Thus $1\frac{7}{8} \times 10 = 3\frac{1}{8} \times 6$, or both equal a moment of 18¾ foot pounds.

Owing to an error, the weight of cast-iron was given as 480 pounds per cubic foot, instead of 450 pounds, which is the weight usually used in ordinary calculations.

Solutions to problems have been received from Z. G. Houck, Bellevue, Ia., No. 6; E. G. Slater, Erie, Pa., No. 9; W. Taylor, Oldham, Eng., No. 9 and 10; F. A. Wing, Providence, R. I., No. 9 and 10.

AN INTERESTING ENGINE.

The readers of MACHINERY will remember an interesting article on the oil engine by Mr. Booth in the September, 1898, issue, which called attention to many defects of this form of motor and which commented upon the need of overcoming them before this type of engine could become a commercial success.

The writer recently visited a shop in Brooklyn, where the motive power was a 9 x 15 inch thirty H.P. kerosene oil engine, running at about 280 revolutions per minute, and found the machinery turning with the regularity that could only come from close regulation. An electric lighting circuit was also operated by the same engine, and the incandescent lamps burned steadily with none of the fitful changes that would surely follow any considerable change of driving motion. The proprietor of the shop, Mr. Secor, will give, in a future issue, some of the commercial advantages of a successful oil engine, and some points of the mechanical construction of a motor that allows of such desirable results will be of general interest.

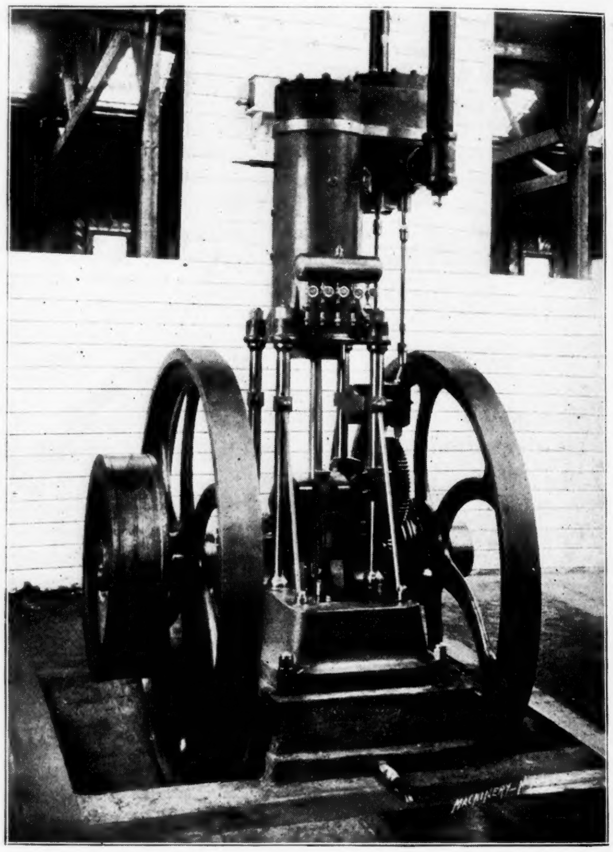


FIG. 1. THE SECOR OIL ENGINE.

Fig. 1 is taken from a photograph of one recently built and is practically the same as the one in operation, the only changes being in minor details. As will be noted, the light but strong form of marine construction is followed and the tie-rods between the cylinder and the bed are turned from high carbon steel. By following this rather expensive method a thirty H.P. motor is built weighing only about 4,500 pounds or 150 pounds per H.P. as against 500 to 700 pounds required by other well-known types. This "open" feature of construction leaves all parts easy of inspection, which is important in an oil motor, as well as a Corliss engine. One of the chief features is, however, the gravity system for feeding the oil to the cylinder instead of pumps, the oil passing through a device somewhat similar to the well-known sight feed lubricator and being at all times under the closest regulation as to quantity delivered. After the proper proportion of oil and air have once been found by the operator, these proportions are constantly maintained by the governor under all fluctuations of load and it is claimed that the same economy of oil used is obtained at the minimum load as well as at the maximum.

The engine which works upon the Otto cycle does not, however, regulate by skipping explosives, but the governor diminishes the charge to the conditions required. Thus the engine works with practically the same economy whether running with full load or at only a fraction of it. A feature referred to by Mr.

Booth in his article, was the liability of an underloaded engine cooling down and stopping from the temperature being so reduced by the non-explosion of charges that the oil would not properly vaporize and mix with the incoming air, but with this engine the trouble is entirely obviated for the reason that the temperature never becomes reduced much below the normal. A charge is fired regularly, but its amount and the consequent strength of the impulse depends upon the load and in no case does it fail entirely so that the impulses are regular with any variation of the load.

The difficulty of getting and maintaining a constant mixture of explosive gas is the serious difficulty in the way of the success of any oil engine, but in this type the regulating mechanism is capable of the most infinitesimal variations by means of an ingenious micrometric device which, when once properly adjusted, maintains the same relations throughout all the fluctuations of power required.

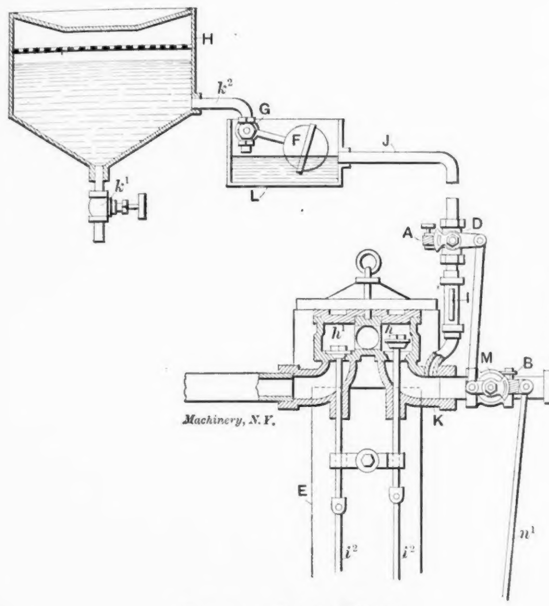


FIG. 2. THE OIL FEED.

Fig. 2 shows the gravity feed arrangement and also the graduating device at A and B. The oil is stored in the large tank H, and admitted to the small tank L as required by the float and valve F and K, from which it runs through the pipe J and valve D to the chamber K, where it mixes with the air coming through the pipe C. The oil passes through valve D and the sight-feed glass I, the amount being regulated by the valve, which is connected to the governor. The amount of opening is adjusted by the screw and segment of a toothed wheel attached to the valve stem, and the same construction is shown at B for the air-valve M. As will be seen the admission and exhaust valves are of the poppet type, which are probably the most reliable for the trying conditions imposed on these engines. The charge is fired by fixed electrodes operated by an Edison-Lalande battery and has the important feature of adjustability so that in starting, the charge is not fired until the piston has passed the center. After the engine is under motion the point of ignition is fixed at the usual position just before the completion of the piston travel.

The simplicity of construction is evident and if the results in actual practice fulfill the claims made, an important advance has undoubtedly been made in oil engine design.

* * *

A QUESTION OF CONTRACTION.

During the latter part of February, the cable roads of St. Louis experienced some difficulty in running because of the cable slots contracting. The trouble was due to the sudden freezing of the material between the paving blocks forcing the slot rails together. The trouble is one inevitably incident to all conduit construction.—Street Railway Review.

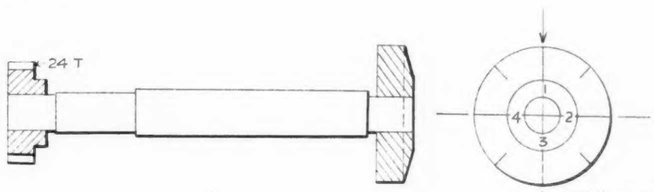
Why, brother! We used to think that cold had a contracting effect. If the "material" between the paving blocks froze, how could the slot rails be forced together?—Electrical Review.

What was the matter with the editor of the "Electrical Review" when he wrote this comment? Was he in a state of non compos mentis or only in his normal condition?

"CATCHING THE THREAD"

IN SCREW-CUTTING AFTER RUNNING THE CARRIAGE BACK BY HAND.

We have lately received inquiries about the best method of determining the correct position of the lead screw, in screw cutting, relative to the lathe spindle, so that the carriage may be run back by hand and the thread of the lead screw caught again without error. Probably the best device for the purpose is a worm-wheel and dial arrangement by which the operator can see at a glance when the lead-screw is in the proper position for closing the nut. In this device a short shaft turns in a bearing attached to the lathe carriage, and has on its lower or inner end a worm-wheel which engages with the lead-screw, and on its other end a graduated dial. The number of teeth in the worm-wheel is some multiple of the pitch of the screw and the number of graduations on the dial must be equal to the number of teeth in the wheel, divided by the threads per inch of the screw. Thus, if the screw were six per inch and the wheel had 24 teeth, the dial should have four graduations, each of which would correspond to one inch travel of the screw.



The following letter was kindly sent by Mr. R. K. Le Blond, of the R. K. Le Blond Machine Tool Co., Cincinnati, O., explaining the principles of a device similar to this which is used on their lathes. The letter was in response to an enquiry from us, and explains the subject very fully and clearly.

"Enclosed please find blue print of our chasing dial, which, upon close scrutiny, will explain itself. We do not claim to be the originators of this idea; as far as we know it was originated by Mr. Gleason, of Rochester, some twenty-five of thirty years ago.

The device consists simply of a gear meshed in the lead-screw rotating a shaft carrying the dial which is divided so that the divisions will mark inches and parts of inches of the travel of the carriage. For instance, the blue print enclosed shows dials used on our 14" lathes which have 6 P. lead-screws. The small gear on the bottom has twenty-four teeth, and requires 4" of travel to give it one revolution,—six threads to the inch go in the twenty-four teeth four times. Our dial on top is made any diameter necessary so that the graduations will show plainly.

The one illustrated is divided into eight parts showing inches and half inches. You will notice the long lines are marked 1, 2, 3, and 4. The short ones have no marks. Now all that is required for chasing is to engage the lead-screws so that some point on the dial, say figure 1, will engage with an index mark on the carriage (shown by the arrow). When you have chased the required distance, throw out the nut, bring the carriage back by hand as in ordinary turning and catch one of the long lines marked 1, 2, 3, or 4,—whichever one comes around first. While the carriage is idle, the motion of the lead screw will revolve the dial slowly. As soon as it is engaged the dial remains stationary, the lead screw simply running around in the same tooth in the small gear, it acting then like a nut. In this way the lead screw is divided into even inches and any number of threads per inch can be cut. It does not make any difference whether the number is 67, 13 or 4. If you are chasing any thread which is divisible by 2 as 2, 4, 6, 8, 10, or 12, any line on the dial, long or short, can be used. If you are chasing 11½ or 29½ you will have to catch every fourth line; that is if you engage the nut on Fig. 1, on the return you will either have to catch it on 1 or 3 or if you engage it with a short line between 1 and 2, on the return it will have to be engaged with the short line between 3 and 4, the dial having to make one-half revolution or a travel of 2" to catch the thread.

This seems a rather long explanation but the principle of the thing can be expressed in a few words. The lead-screw having six threads per inch, any multiple of this, like 6, 12, 18, 24, can be caught without stopping the lathe or using the dial. All even threads come in every ½" and can be chased by engaging the nut with any line on the dial. All odd threads will come in every

inch and can be chased with every numbered line on the dial. All fractional threads have to be caught on the number of inches shown by the denominator of the fraction. For instance, the 12½ fraction being 1-3 would come in on 3". If it were 15 1-5 the fraction being 1-5 would come in on 5", etc.

Beaman & Smith, Providence, R. I., also make lathes with a similar arrangement for catching the thread and we are indebted to them for a description of their device. In view of the explanations just given, however, we think it will not be necessary to do more than refer to its main features to make clear its arrangement.

Taking their 16-inch lathe for an illustration, the lead-screw is 6 per inch, the gear has 12 teeth and the dial should have $12 \div 6 = 2$ divisions. For convenience, however, they use four divisions, but number them consecutively 1-2-1-2. In running the carriage one inch the dial makes one-half revolution. A very complete table is furnished showing what threads can be cut with all possible combinations of the gears and which of these can be caught after running the carriage back by hand.

Regarding fractional threads they write:

"A nut cannot be opened and caught again on fractional threads, excepting in a few special cases where the conditions are such as to bring it right, but there would be no saving of time in doing so, owing to errors the operator might make, and we do not recommend disconnecting on odd threads."

* * *

TOOLS FOR MECHANICS.

The accompanying illustrations show two new tools that are both unique and useful. The screw driver in Fig 1 will appeal to any mechanic who has had anything at all to do with finished work. The usual screw driver has a beveled end, and when considerable pressure is applied will cause more or less trouble by marring the

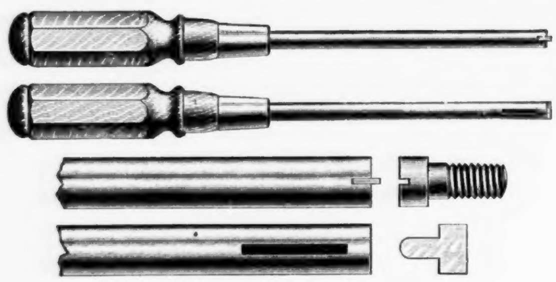


FIG. 1.

slot of the screw or else by slipping out of the slot and marring the work. In the screw driver shown, there are removable steel blades, several of which are furnished with each handle. These blades have parallel sides, are stiffly supported close to the head of the screw, and the head of the screw is so well supported by

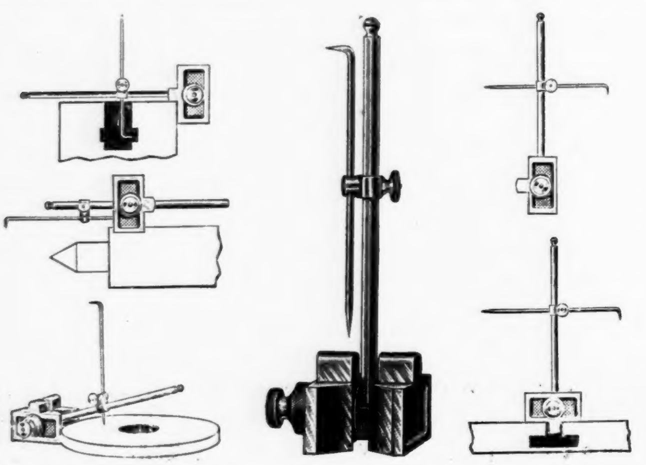


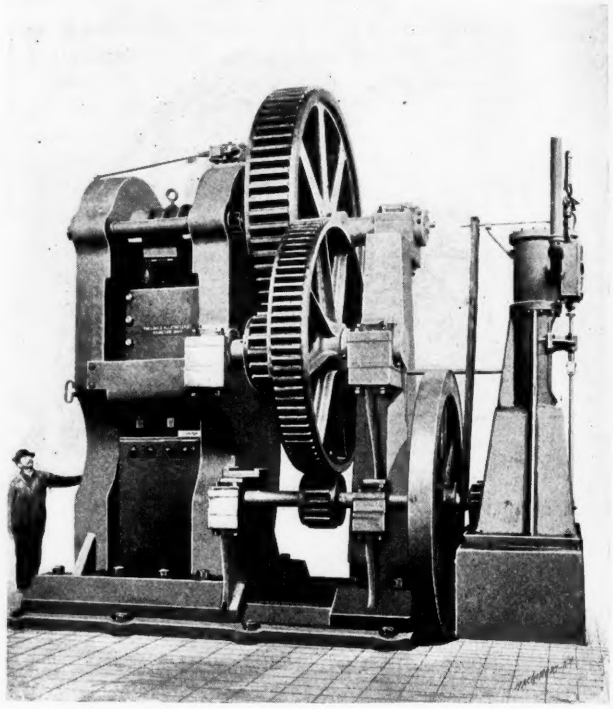
FIG. 2.

the short blade and shank of the driver that a wood screw can be driven "home" without touching the screw with the fingers after it is once in position.

The surface gauge shown in Fig. 2 has the scope of the ordinary gauge, besides being adapted to other uses illustrated in the engraving. It is said to have a very fine and easy adjustment, which is positive whatever the position of the gauge.

A LARGE SHEAR.

Some idea of the immense proportions of some modern tools can be gained from this picture of the huge shear recently built by the Long & Allstatter Co., of Hamilton, O., for the Lorain Steel Co. The figure of the man standing at the left shows that the machine is over three times his height, the actual height being 21 feet and the total weight 250,000 pounds or 125 tons. The power is furnished by the vertical engine to the right, the diam-



A SHEAR FOR CUTTING BLOOMS.

eter and stroke of the piston being 14 x 18 inches. The two housings have a total weight of 108,000 pounds and the cam shaft which operates the shear weighs 10,000 pounds. The stroke is 10½ inches, so that a piece 10 inches thick can be sheared.

This shear was built for cutting blooms and is rated at a capacity equal to 100 square inches or a bloom 10 inches square. If it would punch, at the same ratio, a hole 10 in. in diameter could be cut from 3 in. plate without trouble. Over 17 tons of steel castings were used in the construction.

It will be noted that the machine is mounted on a heavy base, having ways so that in making repairs the outward housing and shear can be slid along, thus rendering it convenient to get at and remove the parts.

* * *

FRESH FROM THE PRESS.

Steam Boiler Practice in its relation to Fuels and Combustion. By Walter B. Snow. Published by John Wiley & Sons, New York. 297 8vo. pages; price, $3.00.

This book by Mr. Snow is to be highly commended. It is probably the best modern work upon fuels, combustion and draft, and includes a great many tables and a large amount of information condensed into a small space that the author has gathered from numerous sources, aside from the results of his own extensive experience. The ground covered is substantially the same, also much of the text, as "Mechanical Draft" by the same writer, and published by the B. F. Sturtevant Co., which book was reviewed in the February, 1898, issue of this paper. The high quality and general character of the book will be recognized at once by the readers of MACHINERY who were subscribers while Mr. Snow's articles upon mechanical draft were running in our columns.

The Slide Rule, by Charles N. Pickworth, Wheeling, S. C. A practical manual of instruction in the use of the slide rule. Published by Emmott & Co., Ltd., London, or D. Van Nostrand Co., New York. Price $1.00. Although the slide rule is quite extensively used there are many who do not fully realize the possibilities of this simple instrument in lessening the labor of calculation and also the liability of errors. This manual gives simple and clear rules together with examples in each case for solving problems met in ordinary business, also those involving the principles of Falling Bodies, Centrifugal Force, The Steam Engine, Strength of Shafting, Moments of Inerta, Lines of Angles, Cosines, Tangents, Solution of Right Angled Triangles, etc.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

NOTE.

Mr. H. Guimer, Baltimore, Md., writes that J. A. P., in question 64, March number, who asks for a book upon axiometric projections, will find a reference to this subject in Warren's descriptive geometry, published by John Wiley & Sons. Several correspondents have also written about the answer to question 73, with regard to a method for obtaining the length of a chord, and have suggested the use of trigonometry. In reply to these suggestions, so kindly offered, we will say that trigonometry was purposely avoided because it was thought that it would not be suited to the needs of the enquirer. We will also add that those asking for technical information must in general wait for a reply until it appears in this department. While it is our wish to do everything possible for the benefit of our readers, we cannot agree to answer technical questions by mail owing to the large amount of time which such correspondence entails.—[EDITOR.]

92. G. W. C. writes: Will you state through MACHINERY whether there is any theoretical difference in the ease of propulsion between twenty-eight and thirty-inch bicycle wheels? 2. Do large sprockets run easier than small ones? A. Thirty-inch wheels, under the same conditions, will roll easier than the twenty-eight-inch size or any smaller size.

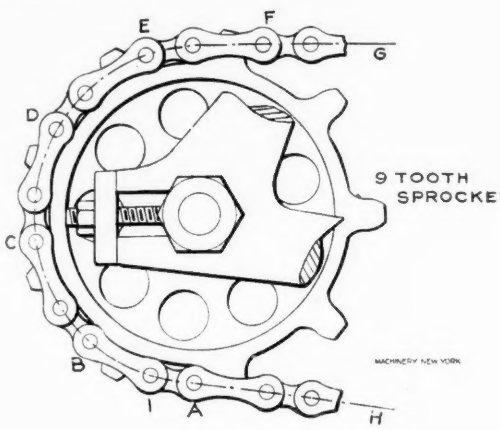


FIG. 1.

It is self-evident that a large wheel will surmount obstructions easier than a small one in practice although theoretically the same amount of power will be required in either case, but with the larger wheel a smaller force applied for a longer time accomplishes the same result that a larger force in a shorter time does with the smaller wheel. The result is, that with the larger wheel, the power required is more uniform and again the larger the wheel the less it falls into the depressions of the roadway.

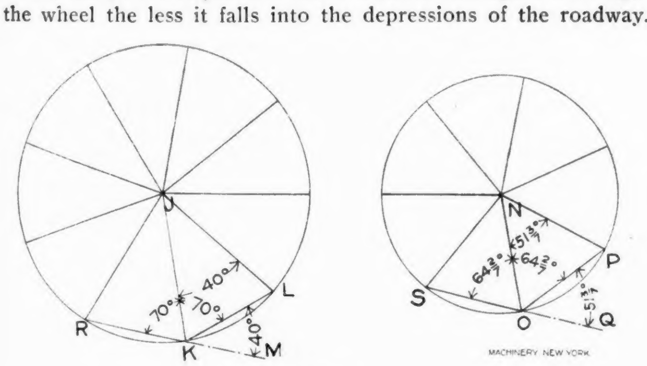


FIG. 2.

This fact does not necessarily imply, however, that a thirty-inch bicycle wheel is better than the twenty-eight-inch size, as there are practical considerations that modify the result. The larger wheel is necessarily heavier and with the drop now given to the crank hanger it is difficult to get a substantial construction of the frame at the junction with the steering head and preserve the present lines, especially with a short reach of frame. 2. The large sprockets, when kept within certain limits are certainly more economical of power than the smaller ones for a number of reasons. In Fig. 1 a 9-tooth sprocket is shown, having the chain in the position it would assume with a front sprocket of 27 teeth. It is evident that with equal pressures on the cranks the tension on the chain will be less with a 9 than with a 7-tooth sprocket and thus be more favorable to lubrication. The friction of approach is also less, but the most favorable factor is the advantage of the larger sprocket in the matter of chain wear. As the pitch of the chain lengthens by wear, while that of the sprocket shortens, it is evident that the larger the sprocket the less this wear will affect the ratio of the pitch line of the two as the diameter of the larger sprocket is less affected by the wear in proportion to its pitch diameter.

An argument often made in favor of the large sprockets is that the bend of the joints of the chain is less. Thus with a 9-tooth the subtended angle of each tooth space is 40°, as shown at J, Fig. 2, and it can be proven that the line of the chain K,M, which is a prolongation of the chord K,R, makes an angle also of 40 with the chord K,L. Disregarding the intermediate joints in each link the angular movement of the chain for each tooth is 40° while by the same method it can be shown that the angular movement with the 7-tooth sprocket is 51 3-7°. But a moment's consideration will prove that this argument is fallacious as the effect of the lessened angular movement of each joint is destroyed by the greater number of joints that pass in one turn of the wheel so that the total angular movement is equal in each case.

93. G. I. A. writes: We were much interested in the results of tests upon steam pumps given on page 197 of your March issue. We should like very much to have the table include tests on compound duplex pumps of about the size of Nos. 6 and 8 (steam cylinders 10" to 12", water cylinders 6 to 8½, stroke 10 inches). We make this suggestion thinking your readers would be interested in knowing how much saving would be effected by compounding.

A. Pumps Nos. 6 and 8, referred to, are used for elevator work and consequently run intermittently and not at their best economy, consuming from 130 to 150 pounds of water per horse-power per hour. Mr. H. E. Walton, the author of the article, states that a compound pump of the same power and used for the same service could be counted on using not more than 60 pounds of water per horse-power per hour.

94. L. E. S. writes: Please give me the rule for finding the horse-power of a compound engine. (b). What is the horse-power of an engine with cylinders 6 and 9 by 10" stroke, running at 220 revolutions? Steam pressure 140 pounds.

A. If the engine is built and running so that it can be indicated, the best method of obtaining the horse-power is to indicate both cylinders, compute the horse-power from the indicator cards from each cylinder separately and add together the results for the total horse-power. The horse-power can be calculated approximately by assuming the whole expansion to occur in the low-pressure cylinder. For example, take the data in your second question, (b). You do not state what the point of cut-off is, but we will assume it to be at one-half stroke in the high-pressure cylinder, making two expansions in that cylinder. The area of the low-pressure cylinder is 2.25 times the area of the high-pressure cylinder, so that the total number of expansions, up to the point where the steam leaves the low-pressure cylinder, will be $2 \times 2.25 = 5.50$. We now have to find what the mean effective pressure will be, assuming the steam to expand 5.50 times from boiler pressure of 140 pounds, the expansion occurring entirely in the low-pressure cylinder. We cannot take the space to explain why it is correct to do this, but think it will be clear if we simply give the hint that a certain quantity of steam expanding a certain number of times can do only a certain amount of work, regardless of the size of the cylinder. To simplify our calculations we will assume that there is neither clearance nor compression and that the back pressure in the condenser is 5 pounds absolute. The absolute initial pressure is $140 + 15$ (the pressure of the atmosphere) $= 155$ pounds. The rule for the mean effect-

ive pressure is: Find the hyperbolic logarithm of the number of expansions; multiply it by the ratio of expansions and the initial absolute pressure; multiply the initial absolute pressure by the ratio of expansions and add the result to the former product; subtract from this the back pressure. Using your data, we have,

hyper. log. of $5.5 = 1.705$; $1.705 \times \frac{1}{5.5} \times 155 = 48.1$; $155 \times \frac{1}{5.5} = 28.2$; $48.1 + 28.2 = 76.3$; $76.3 - 5 = 71.3$ = M. E. P. Now, to obtain the horse-power, we have that the area of the cylinder is $9^2 \times .7854 = 63.62$ sq. in., and the length of stroke = 10 inches = .833 feet. The formula is the familiar one of

$$\text{H. P.} = \frac{2 \times P \times L \times A \times N}{33{,}000}$$

Substituting,

$$\text{H. P.} = \frac{2 \times 71.3 \times .833 \times 63.62 \times 220}{33{,}000} = 50.38.$$

The actual horse-power would be from 10 to 20 per cent. less than this.

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95. G. P. asks: Will you kindly give me formula and explain the proper way to calculate the balance weight of a crank disk for a high-speed, center-crank engine? I would like to balance this engine as perfectly as possible so as to have as little vibration as possible when running at full speed. (b). If all the weight could be placed at a distance of 5 inches from the center of the shaft and opposite to the crank, what weight would be required? (c). How much of this weight is required to balance the connecting-rod and how much the reciprocating motion of the piston and cross-head? Size of engine, 10 x 10; revolutions, 325; weight of piston-rod, etc., 70 lbs.; weight of cross-head, 55 pounds; weight of connecting-rod, 69 pounds; weight of connecting-rod with crank end on scales and cross-head end suspended, 42½ lbs.

A. It is possible to calculate, from a theoretical standpoint, exactly how much weight you will require. If you wish to look into the subject with this degree of thoroughness, however, we shall have to refer you to Professor Thurston's treatise on the steam engine, as the subject is too extensive and involves too much mathematics to be of general interest in this department. A brief consideration will show how many items must be taken into account. We will assume that you wish to balance the horizontal throw of the reciprocating parts so that the engine will not move on the foundation and that the foundation itself is heavy enough to absorb the effect of the vertical throw. There is first the weight of the piston, cross-head and piston-rod, which move back and forth in a straight line; second, there is the weight of the cross-head end of the connecting-rod which moves with the cross-head; third, there is the weight of the crank end of the connecting-rod which may be considered as rotating with the crank. This latter weight is the only one that can be perfectly balanced by a counterbalance. To determine the action of the two ends of the connecting-rod, each end must be weighed separately and the center of percussion found by swinging the rod like a pendulum, alternately from each end. From these data, the centers of gravity of the two ends can be computed. The angularity and length of the connecting-rod affect the result, as does also the distribution of the steam in the cylinder. An engine properly balanced for one point of cut-off and compression may pound when the steam distribution is changed. Engine builders do not go into these detailed calculations, as the final result would not be any better and probably not as good as can be obtained by direct experiment. We know of a case where a Straight-Line engine was balanced by a counterweight placed at an angle with the crank and the engine ran better than with the weight in the usual position, although calculations would have indicated otherwise. The best way to do is to determine approximately the weight required and then, using these figures as a starting point, experiment with greater or less weights until the engine runs quietly. To do this, divide the radius of the crank by the distance from the center of the shaft to the center of gravity of the balance weight. Multiply this quotient by the sum of the weights of the piston, piston-rod, cross-head, connecting-rod and crank-pin. The weight of the counterbalance should be from 2-3 to 3-4 of this result.

(b). Applying this rule to your figures, as far as you have furnished the data, $5 \div 5 = 1$. $70 + 55 + 69 = 194$. $1 \times 194 \times$ 2-3 = 129 and $1 \times 194 \times ¾ = 146$. The weight should be between 129 lbs. and 146 lbs.

(c) It will be evident that we cannot answer this question without giving a calculation that we do not think best to present here.

J. W. K. asks about the proportions of the combustion chamber for a gasoline engine. The diameter of cylinder and stroke are each three inches. In operation the piston draws in a charge of gas through a check-valve during the inward stroke. At the center the check closes and as the piston moves outward the charge is compressed in the crank base until the piston uncovers a port, allowing the gas to rush into the cylinder on the other side of the piston. During the next stroke the gas is compressed into the combustion chamber and fired. In the engine in question the combustion chamber is simply a continuation of the cylinder, extending back three inches, which is equal to the stroke of the engine. Our correspondent says that the engine will not run and thinks it is due to the combustion chamber being too large so that there is no compression of the gas.. He wants to know what the size of the chamber should be.

A. We certainly should not expect the engine to run, since there is no compression whatever as constructed. Good results cannot be obtained without compression, as it can be demonstrated that, with the ordinary engine working on the Otto cycle, or its equivalent, the efficiency depends directly upon the initial compression. We advise making the depth of the combustion chamber not greater than one-third of the length of the stroke, which will give a compression of 70 or 80 pounds.

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96. M. S. T. writes: Please give me the chemical composition of petroleum and the minimum quantity of air required for its combustion.

A. The composition of the crude oil, which is used for fuel purposes, may be taken on an average as follows: Carbon, 84 parts; Hydrogen, 14 parts; Oxygen, 2 parts; total, 100 parts. The air required for combustion may be approximated by the formula,

$$\text{Wt of air} = 12\,C + 36\left(H - \frac{O}{8}\right)$$

Where C = wt. of carbon.
H = " " hydrogen.
O = " " oxygen.

Thus, to burn one pound of oil would require $12 \times .84 + .36 \left(.14 - \frac{.2}{8}\right) = 10.08 + 5.04 - .025 = 15.09$ pounds. This, of course, is less than the actual amount that would be required, since it is not possible to secure perfectly intimate contact between the particles. It may assist you to have also, that one cubic foot of dry air at 72° T weighs .075 pounds and one gallon of crude oil about seven pounds.

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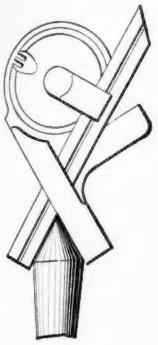
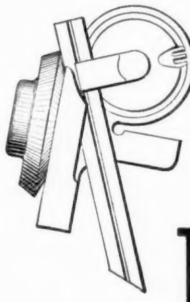
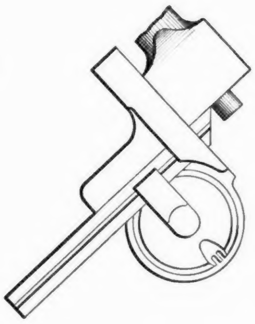
97. C. L. B. writes:

1. The reading of a certain wattmeter at a certain hour is 1,538,250, and the reading of the gas meter at the same time is 289,250. Four hours later the wattmeter reads 1,560,100, and the gas meter reads 293,050. What I would like to know is, how do you calculate the cost of generating electricity using the above readings. The wattmeter readings have to be multiplied by 4 to get the true readings. The price of gas is $1 per thousand. 2. How do you determine the number of gas jets that a 16-candle power, 110-volt lamp is equal to? I understand that one 16-candle power 110-volt lamp, 55 watts, is equal to three 5-foot gas burners. Please explain these questions by giving rules for making the calculations.. The wattmeter and gas meter readings were taken in connection with a gas engine used to furnish the power to run the electric lights. 3. Will you explain how to calculate the radiating surface of pipes for heating by steam and hot water? 4. What is the meaning of the word "cycle" as applied to electrical and gas engine calculations? 5. What is the difference between an indicator card from a gas engine and one from a steam engine?

A.—1. The wattmeter indicates the number of watthours of electrical energy that has been developed, a watthour being one watt of energy supplied for one hour. One horse-power is equal to 746 watts, therefore one watt hour is equal to the one seven hundred and forty-sixth part of a horse power supplied for one hour. The difference between the two readings of the wattmeter is 21,850, and as this has to be multiplied by four to get the true reading, the total amount of electrical energy that has been furnished during the four hours is 87,400 watt hours, and this is equal to 21,850 watt hours as the average rate of supply. As each lamp requires 55







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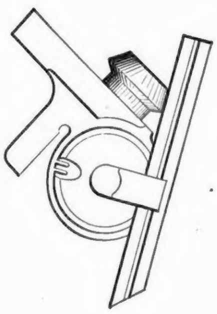

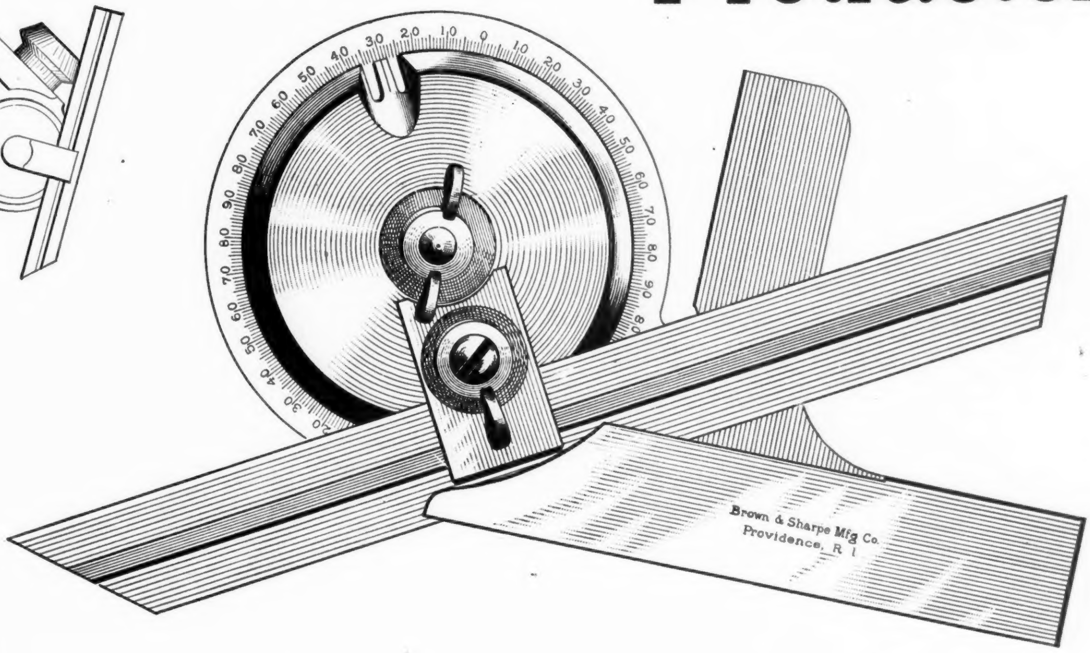

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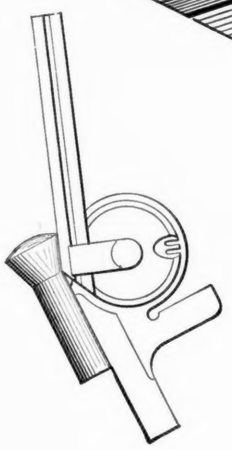

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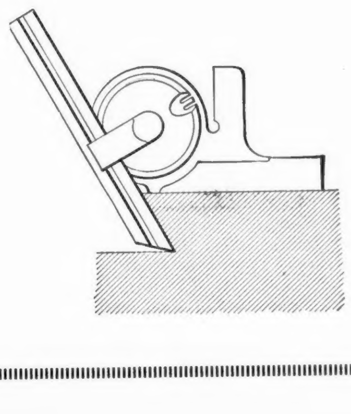

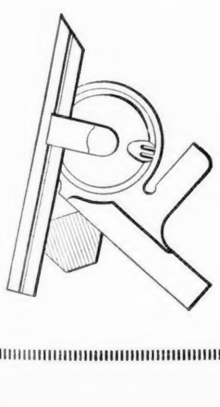

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watts, or 55 watt hours to keep it going for one hour, the total number of lamps should be about 397. The difference between the two gas meter readings is 2,800, which is at the rate of 700 feet per hour, and at $1 per thousand this comes to 70 cents. A kilowatt is 1,000 watts, therefore, by dividing the 70 cents by 21.85 kilowatts we get the cost of gas for the electric energy per kilowatt hour, and it is a trifle more than 3 1-5 cents per kilowatt hour. To obtain the cost per lamp hour divide the kilowatt hour cost by 1,000 and multiply by 55, and this gives .00176 cent, or about 1¾ mills per hour per lamp.

2. The capacity of lights is determined by comparison with a standard which may be any intensity of light desired. In some countries the standard is an oil lamp of a certain size. In this country the standard is a candle of a given size, hence, lights are reckoned as of so many candle-power, by which is meant that they will give as much light as that number of candles of the standard size. A five-foot gas burner gives a light of about 16 candles and this is the intensity of a 16 candle power 110 volt incandescent lamp, therefore, the illuminating power of the two should be about equal.

3. The radiating surface of steam pipes is determined by multiplying the length of the pipe by its diameter, outside, and by 3.1416. If the measurements are taken in inches, the radiating surface will be given in square inches, and if they are taken in feet the result will be given in feet. If the diameter of the pipe is taken in inches, the length must also be taken in inches, that is, the length and the diameter must be taken in the same unit of measurement. The amount of surface required to heat a given amount of air or a space of a given size, depends upon the character of the surface of the pipe, and upon the temperature of the steam and also the temperature to which the air is to be raised. The value of radiating surface has been determined, experimentally, and figures given in the tables found in books treating of the subject are used to determine the heating value of any particular pipe. A rule for calculating the heating capacity of pipe surface from purely theoretical reasoning would have to be very complicated and even then would not be very accurate, as there are a hundred and one things that tend to change the results. On this account, the results obtained by actual experiment are used as a guide.

4. The word cycle, in connection with electrical machinery or gas engines, means one complete circle of operation. An alternating current of electricity starts from a value of zero and grows to a certain value flowing in one direction, it then reduces to zero and begins to increase, flowing in the opposite direction, and after reaching a maximum value again reduces to zero. This operation constitutes a complete cycle, as the action returns to the starting point. In a gas engine when the piston moves away from the end the gas enters and exerts a pressure until the end of the stroke is reached. On the return stroke the gas is exhausted, all of it escaping by the time the piston reaches the starting point. This complete circle of operations constitutes one cycle.

5. There is no difference in the indicator cards of gas and steam engines, except in the shape of the curves; both indicate the pressure acting in the cylinder.

* * *

FRESH FROM THE PRESS.

MACHINE DESIGN Part II., treating of Form, Strength and Proportions of Parts. By Forrest R. Jones, Professor of Machine Design in the University of Wisconsin. Published by John Wiley and Sons, New York. 8vo., 353 pages, illustrated. Price, $3.00.

The first volume under this title treats of mechanism and kinematics, and was noticed in the April, 1898, number of this paper. The present volume demands more than usual attention, because it is the first American treatise on machine design, in the sense in which that term is usually understood, with the exception of notes intended more strictly for college use, like Klein's and Benjamen's. The chapter headings of the book are Bearings and Lubrication; Spur and Friction Gears; Belts and Ropes for Power Transmission; Screws for Power Transmission; Screw Gearing; Screw Fastenings; Machine Keys, Pins, Forced and Shrinkage Fits; Axles, Shafting, and Positive Shaft Couplings; Friction Couplings and Brakes; Fly-wheels and Pulleys; Cylinders, Tubing, Pipes and Pipe-Couplings; Riveted Joints; Frames of Punching, Shearing and Riveting Machines; Selection of Materials.

The general method of treatment is to give sketches and examples from practice, and to supplement these examples with a rigid mathematical treatment. The references to practice are numerous, and represent a great amount of research, which has undoubtedly taken a number of years. The sketches of details are intended to be merely illustrative rather than to serve as a guide to the designer in proportioning the parts. For example, it is quite common in books on design to find a lettered sketch of some machine part, like a bearing, accompanied by a table giving empirical proportions for bearings of different sizes. In this book the author prefers to show simply the general arrangement of the bearing, and to have the student proportion it himself from the principles enunciated. This is undoubtedly the best way in which to instruct students, as it teaches them to be self-reliant, but it makes the book less valuable as a hand-book for draughtsmen.

With regard to the mathematical treatment, there are places where it seems to be excellent and appropriate and others where the treatment given seems to us to be wholly out of place. For example, there is a full discussion of fly-wheels, and of the efficiencies of screws and screw gearing. These are subjects that enable more or less exact demonstrations and that one sometimes wishes to look into. When one does wish to study them, he generally wants to go to the bottom and is glad to have a complete presentation such as Prof. Jones gives. On the other hand, with such a frequently used subject as belting, where an exact demonstration is not possible owing to the extreme variableness of the elasticity, friction, etc., it is somewhat disappointing to find only equations like

$$P = T_n \frac{E^{0.94248\,(1-z)}}{E^{0.94248\,(1-z)} - 1}$$

for ordinary calculations of width of belt such as are liable to arise at a moment's notice, and then to find that it is the sectional area of the belt which is obtained, and that the weight of the belt per cubic inch must be known!

Beyond this we have no adverse criticism except to mention that there are omissions of some subjects that should appear in a complete treatise of machine design, such as ball bearings, cranks, connecting-rods, hooks, chains, flat plates, and numerous other machine parts that are as important elements as couplings and fly-wheels, which are included. We presume, however, that these may be included in future editions. On the other hand, numerous subjects are included which have not been put into book form before, such as a good treatment of slides, and of shrink and force fits (the latter made up of material from MACHINERY). The work can be recommended as well adapted to the instruction of advanced students, and it will prove a serviceable reference book for engineers.

ROPER'S ENGINEERS' HANDY-BOOK, containing facts, formulæ tables and questions on power, fuel, steam, the steam-engine, gas-engine, etc., together with a discussion of the principles of electricity, dynamos, motors, etc. Published by David McKay, 1022 Market street, Philadelphia. Price, $3.50.

This is one of the best-known and most widely-used handbooks for stationery engineers. It now appears in its fifteenth edition, revised and greatly enlarged by Edwin B. Keller and Clayton W. Pike. The book has 850 pages, is bound in morocco, with flap, and will be appreciated and highly valued by any engineer who may have the good fortune to secure a copy. The revisers have brought the text up to date, and the section upon electricity will make the book of increased value to engineers who have electric power plants under their control or plants with electric lighting equipment.

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